

*Speculum Nauticum,*

A

# Looking-Glasse

FOR

## SEAMEN.

Wherein they may behold, how by  
a small Instrument, called the  
PLAIN SCALE, all Nautical Questions,  
and Astronomical Propositions, are very  
easily and demonstratively performed.

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First set forth by *John Affley,* *R*  
Student in Physick, and Practitioner of the  
Mathematicks in *London.*

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The Sixth Edition.

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Whereunto are added, many new Propositions  
in Navigation and Astronomy, and also a third  
Book, shewing a new way of Dialling.

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By *H. P.* and *W. L.*

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LONDON,

Printed by *W. Leybourn,* for *George Hurlock,* and are to be  
sold at his Shop at *Magnus Church-Corner,* in  
*Thames-Street,* near *London-Bridge,* 1662.

Specimen N. 100000



London, 18th July 1841

My dear Sir,

I have the honor to acknowledge the receipt of your letter of the 14th inst.

in relation to the loan of the

specimens of the

British Museum.

I have the honor to inform you that the

specimens of the

British Museum are now in the

possession of the

British Museum.

I have the honor to inform you that the

specimens of the

British Museum are now in the

possession of the

British Museum.

TO THE  
WORSHIPFULL,  
THE  
MASTER, WARDENS, & ASSISTANTS  
OF THE  
TRINITY HOUSE;  
*JOHN ASPLEY,*  
IN  
TESTIMONY OF THE HONOUR  
HE BEARS TO THE  
GOVERNOURS & PRACTISERS  
OF THE ART OF  
NAVIGATION,  
DEDICATES THESE HIS  
FIRST LABOURS.

The Printer to the Reader.

**H**is little book having been well accepted of among Sea-men, being the first fruites of Mr. Aspley's Mathematical Studies, hath passed five Impressions, without any alteration; and so I doubt not might have done still: But because since that time there have been severall bookes put out of this nature, I have procured this to be revised, and severall alterations and additions to be made therein, So that here you have both the old, and a new booke intermingled all in one, with a third part added thereto, concerning Dialling, by a way not formerly published by any. All which I doubt not you will kindly accept of, and receive much delight and profit thereby.

Your. G. H.

TO THE READER

**E R R A T A**

**P**age 34 line 26 read 360. Page. 45. l. 8. r. Distance I M.  
 Page 50. line 13. for 14 O. r. 12. which is  
 just the length of the Gnomon. Page. 50 line. 28. for increase,  
 read decrease, Page 52 line 4. r. H A I. line 18. r. point O. Page  
 57 line 11 r. point L.

Also for some littell faults we shall desire your Pardon.





*Speculum Nauticum,*  
OR THE  
**SEAMANS**  
**GLASSE.**

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The First Book.

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CHAP. I.

*The Explanation of certain Terms of Geometry.*

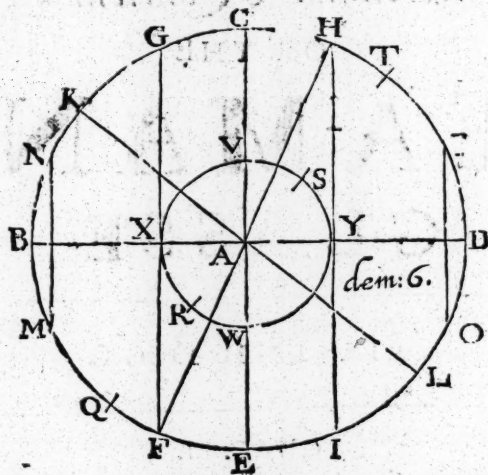


Being intended in this Treatise of the plain Scale, to declare the manner of projection of the Sphere, *in plano*, I have thought fitting first, to shew unto you some terms of Geometry which are necessary for the unlearned to know, (for whose sake chiefly I write this Treatise) before they enter into the definition of the Sphere. First therefore I intend to relate unto you, what a point or prick is, and

and afterward a Line both right and crooked, and such sorts thereof as are appertinent unto the operations and use of this Scale.

*Punctum*, or a point, is the beginning of things, or a prick supposed indivisible, void of length, breadth, and depth: as in the Figure following is noted by the point, or prick A.

*Linea*, or a Line, is a supposed length, or a thing extending it self in length, not having breadth nor thickness, as is set forth unto you by the Line B A D.



*Parallela*, or a Parallel Line, is a line drawn by the side of another line, in such sort that, they may be equidistant in all places. And of such parallels, two only belong unto this work of the plain Scale, that is to say, the right lined Parallel, and the circular Parallel.

Right lined Parallels are two right lines equidistant one from another, which being drawn forth infinitely, would never touch or meet one another, as you may see in the Figure, where the line H I is Parallel unto the line C E, and the line G F is Parallel unto them both.

A circular Parallel is a circle drawn either within or without another circle upon the same center, as you may plainly see by the two circles B C D E, and X V Y W. These circles are both drawn upon the center A, and therefore are parallel the one unto the other. There is another kind of Parallel also, which is called a Serpentine Parallel, but because it is not belonging unto the use of this Scale, I will omit it, and so proceed unto the rest.

*Perpendiculum*, or a Perpendicular is a line raised from, or let fall upon, another line, making equal Angles on both sides, as you may see declared in the figure, wherein the line A C is perpendicular unto the line B A D, making equal angles in the point A.

*Diameter circuli*, or the Diameter of a Circle, is a right line drawn thorow the center of any circle, in such sort that it may divide the circle into two equal parts, as you may see the line B A D is the Diameter of the circle B C D E, because it passeth thorow the center A, and the two ends thereof do divide the circle into two equal parts, in the two extreames B and D, making the semicircle B C D equal unto the semicircle D E B.

*Semidiameter circuli*, or the semidiameter of a circle is half of the Diameter, and is contained betwixt the center, and the one side of the circle, as the line A D is the Semidiameter of the circle B C D E. This Semidiameter contains 60 degrees of the line of Chords, which we sometimes call the Radius.

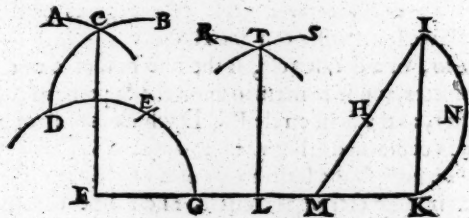
*Semicirculus*, or a Semicircle, is the one half of a circle, drawn upon his Diameter, and is contained upon the Superficies, or Surface, of the Diameter, as the Semicircle B C D which is half of the circle B C D E, and is contained above the Diameter B A D.

*Quadrans circuli*, is the fourth part of a circle, and is contained betwixt the Semidiameter of the circle, and a line drawn Perpendicular, unto the Diameter of the same circle, from the Center thereof, dividing the Semicircle into two equal parts, of the which parts, the one is the Quadrant, or fourth part of the same circle. As for example, the Diameter of the circle B C D E is the line B A D, dividing the circle into two equal parts: then from the center A raise the Perpendicular A C, dividing the Semicircle likewise into two equal parts; so is A B C, or A C D, the Quadrant of the circle B C D E, which was desired.

## CHAP. II.

*The manner how to raise a Perpendicular from the middle of a line given.*

**D**raw first a ground line whereupon you would have a Perpendicular raised, then open your Compasses unto any distance (so it exceed not the end of your line,) placing one foot of the said Compasses in the point from whence the Perpendicular is to be raised, and with the other foot make a mark in the line on either side. Then removing your Compasses unto any other distance that you please, set one foot thereof in one of the marks, and with the other foot make an Arch over the middle point, then with the same distance of your Compasses set one foot in the other mark upon the line, and with the other foot make another Arch of a Circle over the middle Point, so that it may cross the first Arch, and from the meeting of these two Arches, draw a right line unto the middle Point, from which the Perpendicular was to be raised, which line shall be the Perpendicular desired.



Example, suppose your Base or ground line whereupon a Perpendicular is to be raised be the line F L K, and from L the Perpendicular is to be raised, set one foot of your Compasses in the Point L, and with the other, make the marks G and M on both sides of the point L, then opening your Compasses wider, set one foot in the point M, and with the other draw the Arch S over the point L, then

then with the same distance of your Compasses, set one foot in G, and with the other make the Arch R, crossing the Arch S in the point T, then from T draw the line T L, which line is perpendicular unto the line F L K from the point L, which is the perpendicular desired.

CHAP. III.

*To let a Perpendicular fall from any Point assigned, unto the middle of a line.*

**L**ET the line whereupon you would have a Perpendicular let fall be the line F L K, and the point assigned to be the point T, from whence you would have a Perpendicular let fall upon the line F L K, first set one foot of your Compasses in T, and open your Compasses unto any distance so that it be more than the distance T L, which here we suppose to be the distance T M; then make in the line F L K the marks G and M, then with your Compasses take the one half of G M, which is the point L, then from L draw a line unto the point T, so the line T L shall be the Perpendicular, which was desired to be let fall from the assigned point T unto the middle of the line F L K.

CHAP. IV.

*To raise a Perpendicular upon the end of a Line.*

**S**UPPOSE the line whereupon you would have a Perpendicular raised, be the line F L K, and from the point F a Perpendicular is to be raised: first open your Compasses unto any distance, which here we put to be the distance F G, and set one foot of your Compasses in the point F, and with the other draw the Arch D E G, then set one foot of your Compasses in the point G, and with the other draw the Arch E; then placing one point of your Compasses in E, with the other draw the Arch D B; then place your

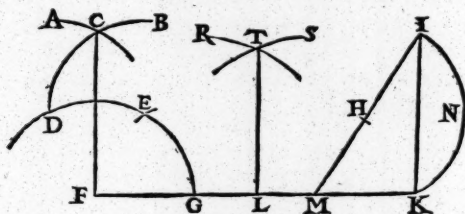
Compasses

Compasses in D, and with the same distance draw the Arch A, cutting the Arch D B in C, then draw a line from C unto the end of the line F L K, unto the assigned point F, so shall the line C F be a Perpendicular raised from the end of the line F L K, and from the assigned point F.

## CHAP. V.

*To let a Perpendicular fall from any point assigned unto the end of a Line.*

**L** E T the line F L K be the Base or ground line, and from the point I a Perpendicular is to be let fall upon the end of the line at K, first from the assigned point I, draw a line unto any part of the Base, which shall be the line I H M, then find the middle of the line I M, which is at H; place therefore one foot



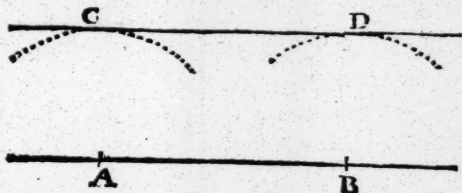
of your Compasses in the point H, and extend the other unto I, with which distance draw the Arch I N K upon the Center H, cutting the Base or ground-line in the point K, then draw the line K I, which line shall be the Perpendicular desired.

## CHAP. VI.

*A right Line being given, how to draw another parallel there unto at any distance required;*

**L** Et the line being given A B, unto which it is required to draw another right line C D which shall be parallel to the former line A B, and at the distance A C.

First open your Compasses to the distance A C, then set one foot in the point A, with the other describe the Arch C; again, place one foot in B, and with the other describe the Arch D; Then draw the line C D, so that it may only touch the two Arches C and D, so shall the line C D, so drawn, be parallel to A B, and at the distance required.



## CHAP. VII.

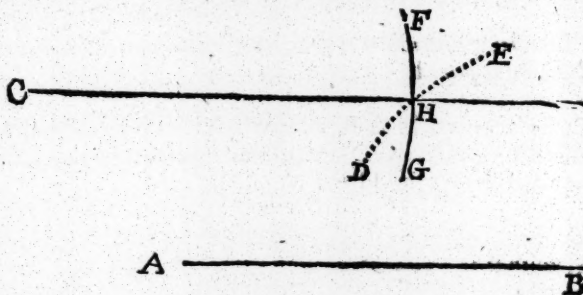
*A right line being given, how to draw another parallel thereunto, which shall also pass through a point assigned.*

**L** Et A B be a line given, and the point assigned be C: and let it be required to draw another line parallel thereunto, which shall pass through the given point C.

First, take with your Compasses the distance from A to C, and



C, and placing one foot thereof in B, with the other describe the Arch D E, Then take in your Compasses the whole line A B, and placing one foot in the given point C, with the other foot describe



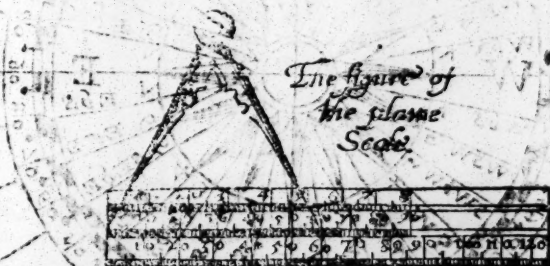
the Arch F G, crossing the former Arch D E in the point H. Lastly, if you draw the line C H, it shall be parallel to A B.

**N**OW I doubt not but you understand the way to let fall, or to raise any manner of Perpendicular line, either from, or upon any part of a line: as also to draw lines parallel one to another at any distance required, therefore now I intend to proceed unto the main point here aimed at, which is, to declare, and make known unto you the several operations performed by the plain Scale, which though it be in use with very few, yet it is most necessary for Sea-men, because all questions in Navigation are thereby easily and plainly wrought. And also all questions in Astronomy (belonging unto the expert, and industrious Sea-men) may both speedily and easily be wrought by the same Scale: in regard whereof I have declared in this little Book, that knowledge (which God hath been pleased to bestow upon me) concerning the necessary use and practice thereof; hoping that you will as kindly accept it, as it is freely offered unto your courteous considerations.

CHAP. VIII.

Of the description of the Scale.

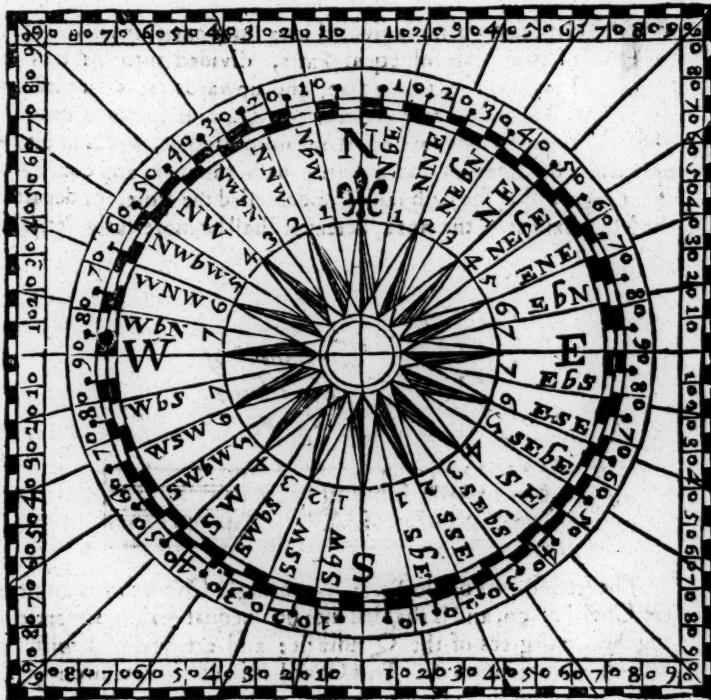
**T**His Scale usually is divided into three parts, the first whereof is a Scale of equal Parts, divided into *Miles*, or *Leagues*, from 1 unto 100, and upwards, at your pleasure, and numbred with 10, 20, 30, 40, and so forth unto the end. All these divisions are equal one unto another, and is in use for to measure the *Leagues* that any ship hath run upon any course, or the *Leagues* that she hath raised or depressed the *Pole*, or departed the *Meridian*, as in the work, hereafter shall be more fully declared.



The second part of the Scale, is the single Chorde of a circle, or the Chord of 90, and is divided into 90 unequal divisions, representing the 90 degrees of the Quadrant: and are numbred with 10, 20, 30, 40, &c. unto 90. This Chord is in use to measure any part or Arch of a circle, not surmounting 90 degrees: The number of these degrees from 1 unto 60 is called the Radius of the Scale, upon which distance all circles are to be drawn, whereupon 60 of these Degrees are the Semidiameter of any Circle that is drawn upon that Radius.

The third part of the Scale is divided into eight parts, representing the Points or Rumbes of the *Mariners Compass*; which in all

are 32 points : but upon the Scale there are only 8 reckoned, which is but one Quadrant or quarter of them, being to be reckoned from the Meridian of North and South both wayes, as you may see more plainly by thisfigure, representing the order of the points of the Compasse.



It is usuall also to have another line placed upon your Scale, to shew you how many leagues make a degree of longitude in every latitude, concerning which you shall have directions in the 14 Chapter following.

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|   |   |   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | % |
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line A B, cuts the Meridian line A F in the point F: So that if you take the distance F A with your Compasses, and apply it to the scale of equal leagues, you shall find it is just 83 leagues, which counting 20 leagues to a degree, makes 4 degrees 9 min. and so much you have altered your latitude by the said course, which degrees and minutes being added to, or subtracted from the latitude of the place you came from, according as your course requires, shews you alwaies the true latitude you are in.

Likewise from this point D, take with your Compasses the distance D F, and you shall find it by your scale of equal leagues to be 56 leagues, and so much you are departed from your first Meridian to the West-ward; which when you are near the Equinoctial, where the degrees of longitude are equal to the degrees of latitude, would shew the longitude, by taking 20 leagues for one degree, &c. so it would be two degrees, and 48 min. for your difference of longitude, from your first Meridian A F. But in other places, you must first learn how many leagues make a degree of longitude about that latitude where you are, and so turn your leagues of distance from the Meridian, into degrees and minutes of longitude, of which more hereafter, Chap. 14.

I have been the larger in these two Propositions, because they are the first, for the better understanding of all the rest; and because they are most necessary, for thereupon depends the knowledge of the true Traverse point, and the keeping of your dead reckoning. Now because this cannot alwaies be kept exactly, it is to be corrected by the observation of the latitude, according to this following proposition.

CHAP. X.

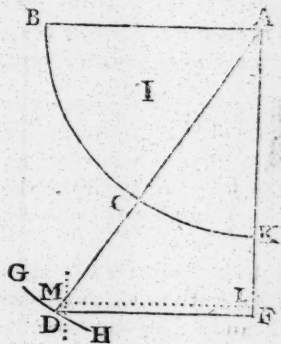
*Knowing the difference of latitude of two places, and the Rumb you have sailed upon, to find the leagues you have sailed, and the difference of Meridians.*

*The Pole depressed four degrees and the Rumb South-West by South or the third from the Meridian, to find your true Traverse point, viz. how far you have sailed, and how much you are departed from your first Meridian.*

In the first figure

**D**raw the lines as in the former Chapter, so that *AKF* may represent the Meridian line, and *ACD* may represent the third Rumb from the meridian; then because you have altered your latitude 4 degrees, which make 80 leagues, take

80 leagues with your Compasses out of your Scale, and set them upon the meridian line *AF*, from *A* to *L*: Then keeping the same distance of your Compasses, draw the line *LM* parallel to *AB*, (or else you may erect *LM* perpendicular to the line *AF*, in the point *L*) and mark where the said *LM* crosseth the Rumb line *ACD*, which is in the point *M*. This point *M* is the true Traverse point, the leagues sailed are shewed by the line *AM*, which being measured in the Scale, will be found to be 96 leagues and an half, and the departure from the Meridian is *LM*, which is 54 leagues.



Now by this Proposition (as I said) you may correct your dead reckoning; for suppose by the former proposition you reckon you had sailed 100 leagues upon the third Rumb, then as you see there, you should have been at the point *D*, and have altered your latitude

83 leagues



83 leagues, and departed from your Meridian 56 leagues; but now suppose that by a good observation of the latitude, you find that you have altered the latitude onely 80 leagues, from A to L, by drawing this line LM, which croseth the Rumb or Ships way in M, you may conclude your true Traverse point to be at M, so that you have sailed only from A to M, which is 96 leagues  $\frac{1}{2}$ , and departed from your Meridian 54 leagues. So that as you are short of the latitude you reckoned for 3 leagues or 9 min. you are also short of your way you reckoned 3 leagues  $\frac{1}{2}$ , and two leagues less in your departure from the Meridian. And this you must account for your true reckoning, being thus corrected.

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### CHAP. XI.

*By the difference of the latitudes of two places and the distance between their Meridians, to find the Rumb by which you must sail from the one place to the other, and how far it is from the one place to the other?*

*The difference of latitude between the two places is 4 deg. 9 min. and the distance between the two Meridians is 55 leagues, and it is required to find the Rumb from the one place to the other.*

**I**N the former figure draw the quadrant A K C B, then turn your four degrees 9 min. of latitude into leagues, it maketh 83 leagues, which you must place upon the meridian line from A to F. And from the point F draw the line FD parallel to the line A B. Then open your Compasses to the distance of the meridians which is 56 leagues, and set it on the line FD, from F to D. Then lay your Ruler by this mark D and the Centre A, and draw the line A C D. Then mark where this line cuts the quadrant, which is in the point C, and setting one foot of your Compasses in the point C, open the other to K, and keeping your Compasses at that distance C K, measure it upon your Scale, either in the line of Chords, or in the line of Rumbs, you shall find it to be in the one 33 deg. 45 min. and in the other just the third Rumb from the meridian. So that the Rumb from A to D is South-west and by South, and the Rumb from D to A is the Rumb opposite thereunto, which is North-east and by North.

Then



Then for the distance between the two places in the Rumb, let one foot of your Compasses in the one place at A, and open the other to the other place at D, and the length of the line A D incasured in the Scale of leagues, shews the distance between them to be just 100 leagues.

These three (or rather these six) Propositions, (for they are each of them double) are the most usefull and necessary in the art of Navigation. By the first of these, knowing the point of the Compass you sail upon, and judging how many leagues you have sailed thereon, you know and are able to give a reasonable account where you are, both in respect of latitude and longitude. By the second having a fair observation of the latitude at any time, you may more perfectly know where you are; and thereby correct your former account. And by this third you may know how to direct your course from any place to your desired haven. So that in effect you need no more, but yet for your better instruction by variety of cases and examples, I shall proceed.

## CHAP. XII.

*The difference of Latitude and the leagues sailed being given, to find the distance from the Meridian, and the Rumb you have sailed upon.*

*Sailing 100 leagues between South and West, untill the Pole be depressed 4 deg. 9 min. the distance from the Meridian is demanded, and what Rumb you have sailed upon?*

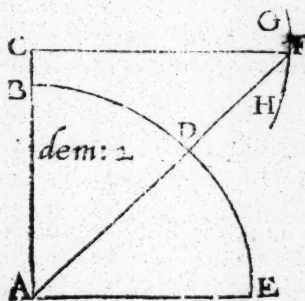
IN the first figure draw the Quadrant A K C B, as in the former Chapters, and then reduce your degrees of latitude into leagues, so 4 deg. 9 min. make 33 leagues, which you must take with your Compasses out of your Scale of leagues, and set them off in this Meridian line from A to F. Then from the point F draw the line F D, parallel to the line A B, which you may do with the foresaid distance of your Compasses. Then open your Compasses unto your distance sailed, which is 100 leagues, and setting one foot of your Compasses in the point A, with the other draw the little Arch

Arch H G, cutting the line F D in the point D. So the line F D measured in the Scale of leagues, shall shew you the distance from the Meridian, which is 56 leagues, and if you draw the line A C D, it is the Rum's line upon which you have sailed, and the Arch K C measured in the Scale of Rumbs, shews it to be the third Rumb from the Meridian, or South-west by South.

## CHAP. XIII.

To find the distance of any Island from you, that you may discern  
at two stations, knowing the point of the Compasse, the Island bea-  
reth unto each of the stations.

*Suppose, being at Sea you discover an Island bearing North-east off you, which place let it be your first station, and then sailing seven leagues full North you observe the Island to bear full East off you, which let be the second station; the demand is to find the distance of the said Island from both the said stations?*



**I**N the second figure, or demonstration, let A be the first Station, and upon the Center A draw the Quadrant A B D E; Then in regard you found the Island to bear North-East from you, take 4 of your 8 points of the Compass out of the Scale, and place them upon your Quadrant from B to D, then from the Center A by the point D, draw the line A D F, representing the visuall line: passing

between your fight and the Island, being at the first station A. Then seeing when you had sailed 7 leagues North, you observed the Island to bear full East off you, let off the said 7 leagues from A to C, (reckoning every 10 leagues of your Scale to be but one) and from this point C, which is the second station, draw the line C F parallel

to A E, and it will cut the line A D F in the point F: So shall the point F, be the place of the Island desired, and the distance A F, is the distance of the Island from the first station, viz. 9 leagues 90 parts or almost 10 leagues: Likewise the distance from C, to F, is the distance of the Island from the second station, which is just seven leagues. And by this manner of work, you may find the distance of any Island or head land from you, or you may take the distances of as many places as you will or can see at any two such stations, and by the crossing of their visuall lines, find their position and distances each from other.

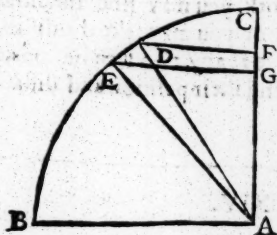
CHAP. XIV.

To find how many leagues, miles, and parts do make one degree of longitude in every latitude.

Note, All this while we have been sailing according to the Rules of the plain Chart, which supposeth the degrees of longitude to be equal to the degrees of latitude, in all latitudes, but this is very false and erroneous; it being true only in places near the Equinoctiall, where every degree of longitude contains 20 leagues, as the degrees of latitude do; But in places near the Poles it alters very much, so that in the latitude of 60 degrees, 10 leagues make a degree of longitude: and in other latitudes the degrees of longitude alter, as in this little Table, which sheweth at what degree and minute of latitude, any number of leagues make a degree of longitude, by which you may divide a Line upon your Scale for your ready use.

| Leagues in one Degree. | 20 | 00 d | 00 m | Leagues in one Degree. | 10 | 00 d | 00 m |
|------------------------|----|------|------|------------------------|----|------|------|
|                        | 10 | 18   | 11   |                        | 9  | 63   | 15   |
|                        | 18 | 25   | 50   |                        | 8  | 66   | 25   |
|                        | 17 | 31   | 47   |                        | 7  | 69   | 31   |
|                        | 16 | 36   | 52   |                        | 6  | 72   | 32   |
|                        | 15 | 41   | 25   |                        | 5  | 75   | 31   |
|                        | 14 | 45   | 34   |                        | 4  | 78   | 28   |
|                        | 13 | 49   | 27   |                        | 3  | 81   | 22   |
|                        | 12 | 53   | 08   |                        | 2  | 84   | 16   |
|                        | 11 | 56   | 38   |                        | 1  | 87   | 08   |

Now to return to the Question, and shew you by demonstration how to find how many leagues, miles, and parts, make a degree of longitude in any degree of latitude?



**T**ake 60 parts out of your Scale of equal parts, which you must reckon for miles, and count three of them to a league, and therewith draw the quadrant A B C; then from the point B set off the degree of the latitude proposed (which for example, let it be 58 deg. 54 m.) from B to D, then from the point D draw the line D F parallel to A B, so shall the length of this line D F, being measured in your Scale of leagues, shew you the number of leagues and miles, which answer to a degree of longitude in the said latitude at 58 deg. 54 m. which you shall find to be 31 miles, or 10 leagues and one mile. So also B E being the Arch of 51 deg. 55 min. the line E G shews one degree of longitude to be 37 miles, or 12 leagues and one mile.

The larger you make your Quadrant, the more exact will the work be, and shew the leagues and miles more exactly, which you may make into a Table, as this following.

| Latitude | Leagues | Miles | Parts |
|----------|---------|-------|-------|
| 11       | 81      | 67    | 10    |
| 12       | 82      | 68    | 11    |
| 13       | 83      | 69    | 12    |
| 14       | 84      | 70    | 13    |
| 15       | 85      | 71    | 14    |
| 16       | 86      | 72    | 15    |
| 17       | 87      | 73    | 16    |
| 18       | 88      | 74    | 17    |
| 19       | 89      | 75    | 18    |
| 20       | 90      | 76    | 19    |
| 21       | 91      | 77    | 20    |
| 22       | 92      | 78    | 21    |
| 23       | 93      | 79    | 22    |
| 24       | 94      | 80    | 23    |
| 25       | 95      | 81    | 24    |
| 26       | 96      | 82    | 25    |
| 27       | 97      | 83    | 26    |
| 28       | 98      | 84    | 27    |
| 29       | 99      | 85    | 28    |
| 30       | 100     | 86    | 29    |

A Table

# The Sea-mans Glass.

91

A Table shewing how many leagues, miles, and hundred parts of a mile make one degree of longitude in any latitude.

| Latitude | Leagues | Miles | Parts | Difference | Latitude | Leagues | Miles | Parts | Difference | Latitude | Leagues | Miles | Parts | Difference |
|----------|---------|-------|-------|------------|----------|---------|-------|-------|------------|----------|---------|-------|-------|------------|
| 0        | 20      | 0     | 0     | 1          | 30       | 17      | 0     | 96    | 53         | 60       | 10      | 0     | 0     |            |
| 1        | 19      | 2     | 99    | 3          | 31       | 17      | 0     | 43    | 55         | 61       | 9       | 2     | 09    | 91         |
| 2        | 19      | 2     | 96    | 4          | 32       | 16      | 2     | 88    | 56         | 62       | 9       | 1     | 17    | 92         |
| 3        | 19      | 2     | 92    | 7          | 33       | 16      | 2     | 32    | 58         | 63       | 9       | 0     | 24    | 93         |
| 4        | 19      | 2     | 85    | 8          | 34       | 16      | 1     | 74    | 59         | 64       | 8       | 2     | 30    | 94         |
| 5        | 19      | 2     | 77    | 10         | 35       | 16      | 1     | 15    | 61         | 65       | 8       | 1     | 36    | 94         |
| 6        | 19      | 2     | 67    | 12         | 36       | 16      | 0     | 54    | 62         | 66       | 8       | 0     | 40    | 96         |
| 7        | 19      | 2     | 55    | 13         | 37       | 15      | 2     | 92    | 64         | 67       | 7       | 2     | 44    | 96         |
| 8        | 19      | 2     | 42    | 16         | 38       | 15      | 2     | 28    | 65         | 68       | 7       | 1     | 47    | 97         |
| 9        | 19      | 2     | 26    | 17         | 39       | 15      | 1     | 63    | 67         | 69       | 7       | 0     | 50    | 97         |
| 10       | 19      | 2     | 09    | 19         | 40       | 15      | 0     | 96    | 68         | 70       | 6       | 2     | 52    | 98         |
| 11       | 19      | 1     | 90    | 21         | 41       | 15      | 0     | 28    | 69         | 71       | 6       | 1     | 53    | 99         |
| 12       | 19      | 1     | 69    | 23         | 42       | 14      | 2     | 59    | 71         | 72       | 6       | 0     | 54    | 99         |
| 13       | 19      | 1     | 46    | 24         | 43       | 14      | 1     | 88    | 72         | 73       | 5       | 2     | 54    | 100        |
| 14       | 19      | 1     | 22    | 26         | 44       | 14      | 1     | 16    | 73         | 74       | 5       | 1     | 54    | 100        |
| 15       | 19      | 0     | 96    | 28         | 45       | 14      | 0     | 43    | 75         | 75       | 5       | 0     | 53    | 101        |
| 16       | 19      | 0     | 68    | 30         | 46       | 13      | 2     | 68    | 76         | 76       | 4       | 2     | 52    | 101        |
| 17       | 19      | 0     | 38    | 32         | 47       | 13      | 1     | 92    | 77         | 77       | 4       | 1     | 50    | 102        |
| 18       | 19      | 0     | 06    | 33         | 48       | 13      | 1     | 15    | 79         | 78       | 4       | 0     | 48    | 102        |
| 19       | 18      | 2     | 73    | 35         | 49       | 13      | 0     | 36    | 79         | 79       | 3       | 2     | 45    | 103        |
| 20       | 18      | 2     | 38    | 37         | 50       | 12      | 2     | 57    | 81         | 80       | 3       | 1     | 42    | 103        |
| 21       | 18      | 2     | 1     | 38         | 51       | 12      | 1     | 76    | 82         | 81       | 3       | 0     | 38    | 104        |
| 22       | 18      | 1     | 63    | 40         | 52       | 12      | 0     | 94    | 83         | 82       | 2       | 2     | 35    | 103        |
| 23       | 18      | 1     | 23    | 42         | 53       | 12      | 0     | 11    | 84         | 83       | 2       | 1     | 31    | 104        |
| 24       | 18      | 0     | 81    | 43         | 54       | 11      | 2     | 27    | 86         | 84       | 2       | 0     | 27    | 104        |
| 25       | 18      | 0     | 38    | 45         | 55       | 11      | 1     | 41    | 86         | 85       | 1       | 2     | 23    | 104        |
| 26       | 17      | 2     | 93    | 47         | 56       | 11      | 0     | 55    | 87         | 86       | 1       | 1     | 18    | 105        |
| 27       | 17      | 2     | 46    | 48         | 57       | 10      | 2     | 68    | 88         | 87       | 1       | 0     | 14    | 104        |
| 28       | 17      | 1     | 98    | 50         | 58       | 10      | 1     | 80    | 90         | 88       | 0       | 2     | 09    | 105        |
| 29       | 17      | 1     | 48    | 52         | 59       | 10      | 0     | 90    | 90         | 89       | 0       | 1     | 05    | 104        |
| 30       | 17      | 0     | 96    |            | 60       | 10      | 0     | 0     | 90         | 90       | 0       | 0     | 0     | 105        |

## CHAP. XV.

The difference of latitude, and the Rumb or distance sailed being known, to find the distance of the Meridians, and thereby to find the degrees and minutes of the difference of longitude in any latitude.

*Sailing from the North parallel of 56 degrees and 5 min. latitude, 100 leagues upon the third Rumb from the Meridian, viz. South-west and by South untill I find the Pole is depressed 4 deg. 9 m. and the Meridional distance 56 leagues; the longitude is desired thereby?*

In the first figure

**D**Rawn the Quadrant as is shewed before, then reduce your 4 deg. 9 min. of latitude into leagues, it makes 83 leagues, which set off upon the meridian line from A to F. Then upon the Rumb line ADC set off the distance sailed from A to D, and after, by these two points, draw the line FD; So shall D represent the place of the Ship, and as AF is the difference of latitude, so FD is the difference of meridians, which measured in your Scale of leagues is 56 leagues.

Now to reduce this 56 leagues into degrees of longitude, you must consider from what latitude you have sailed, and to what latitude you are come, viz. from latitude 56 d. 5 m. to 4 deg. 9 min. less, which is 51 d. 56 m. and take the middle latitude (or somewhat more) between the two places, which in this example falls out to be 54 d. or m. Then by the Table in the former Chapter, find out how many leagues and miles in the said middle latitude make one degree



degree of longitude, and you shall find in that Table, that in the latitude of 54 d. there is but 11 leagues, and 2 miles, and 27 parts in one degree of longitude; Therefore open your Compasses upon your Scale of leagues, to this 11 leagues, 2 miles, 27 parts; and keeping your Compasses at that distance, set one foot of them at 56 leagues in your Scale of leagues, or in the line D F in the figure, (or upon the like line in your Chart at any time) either at F or D, and measure how many times you find that distance either to the end of your Scale coming backward, or in the line D F, for so many degrees is the difference of longitude, and if any odde part remain, you may proportion it by your eye, judging it to be a quarter, a third, an half, or any part more or less of a degree, which you may either reckon by parts, or 15, 20, 30 &c. minutes,

Thus this line D F being 56 leagues, opening your Compasses to 11 leagues 2 miles 27 parts, you will find this distance in it, 4 times and 3 quarters; so that the difference of longitude is 4 deg. 45 min.

Or you may reduce it into miles and work by the rule of proportion, so you shall find

As 11 leagues, 2 miles, 27 parts, that is 35 miles 27 parts. 35, 27

To one degree of longitude in the latitude of 54 d. 01, 00

So is 56 leagues, or 168 miles. 168, 00

To 4 degrees, 76 parts. 04, 76

But if your Scale be large, the other way with your Compasses will give you the degrees and parts of longitude as exactly as you need for most uses.

Also if the latitude fall not out in equal parts, you may find out for your odde minutes by proportion, for which purpose I have set the differences between each degree in the Table.

So that as one hundred parts or 60 minutes being one degree, to the difference in the Table between the two next degrees;

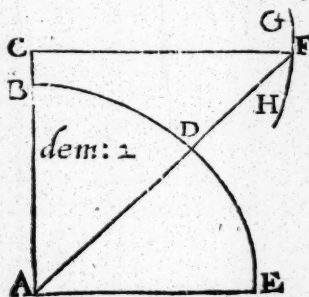
So the odde hundred parts or minutes of latitude, to the parts and minutes proportional to be allowed.



## CHAP. XVI.

*Sailing from the South latitude of 60 degrees, 31 min. and from longitude 25 degrees, 24 min. 99 leagues, upon a South-west course: the latitude and longitude of the second place is demanded.*

**I**N the second demonstration, draw the Quadrant *A B C D E*, as is formerly taught, then in regard you sail South-west, take 4 points of the Compass from your Scale, and place them from *B* unto *D*, then by the point *D* draw the line *A D F*, then place your ninety nine leagues upon the line *A D F*, from *A* unto *F*, so shall *F* be the place of your Ship. Then from *F* draw the line *F C* parallel unto *A E*, cutting the line *A B C* in *C*, so shall the distance *C A* be the leagues you have run South, which is seventy leagues, or 3 deg. 30 minutes, which being added to the latitude from whence you departed,



makes 64 deg. and 21 minutes for the latitude of the second place: then take the distance *C F*, and apply it unto the line of equal parts, and you shall find it likewise 70 leagues: Then finding the middle latitude 62 degrees 36 minutes in the Table, Chap. 14. you shall find that 9 leagues and 0 miles, and 61 parts, do alter a degree of longitude in that latitude. Then opening the feet of your Compasses to 9 leagues 0 miles 61 parts, in the Scale of equal leagues, and keeping the Compasses at that distance, see how many times that distance is in the line *C F*, which is seven times and somewhat above an half, the true difference of longitude being 7 deg. 36 m. which being subtracted from the longitude from whence you departed, leaves 17 degrees and 48 minutes for the longitude of the second place.

CHAP. XVII.

*A Ship sailing from the North Parallel of fifty degrees, having an hundred leagues to sail South-west, and by West, by the way is enforced by contrary winds to sail upon several points of the Compass, first sailing thirty leagues upon a direct course, then West North-west twenty leagues, then South sixty leagues, the question is to find the latitude of the second place, how far it is to the place wherunto you are bound, the distance of the Rumb that is betwixt them, the distance that you are from your first Meridian, and thereby the difference of longitude.*

**I**N the third demonstration, draw the line A D, and from the point A, raise the perpendicular A B, then open your Compass unto the Radius of your Scale; and place one foot thereof in the center A. and with the other draw the Quadrant B C D, then take three points of the compass & place them upon the Quadrant from D. unto C, then from the Center A, by the point C, draw the line A C L, too Leagues in length, which is the true course you are to sail, Then in regard you sayed thirtie leagues direct, take thirtie leagues from your Scale of equall parts, and place them upon the line A E C, it extends from A unto E; then in regard you turned your Course, West, Northwest, from the Center E, draw the Line E G parallel unto A. D. and again from the center E draw the line E H perpendicular to E G, and parallel to A B, then

with the distance of the Radius, set one foot of your compasses in the center E, and with the other draw the Quadrant GMH, and in regard you sayled West, Northwest, which is two points from the West Northward, take from your Scale two points of the Compass, and place them upon the Quadrant GMH, from G unto M, then from the center E unto the point M, draw the line EFM, then take 20 Leagues with your Compasses from the Scale of equall parts, and place them upon the line EFM, from E unto F, then is your Ship in the point F. Lastly, in regard you run South 60 Leagues from F, draw a Line Parallel unto the Meridian AB, which is the line FI, then take from your Scale of equall parts sixtie Leagues, and place them from F, unto I, then is your Ship in the point I: then last of all is to be found how far it is to the place where unto you were bound, the distance of the Rumb that is betwixt you, the degrees and minutes you have raised the Pole, the distance of departure from the first Meridian, and thereby the difference of Longitude: and that you may so doe, first draw the line OIK, Perpendicular unto the line IF in the point I, and with your Compasses opened unto the distance of the Radius, set one foot of your Compasses in the Center I, and with the other draw the Quadrant KNF, then in regard your ship is in the point I, and the place whereunto you are bound is the point L, therefore from I, thorow the point L draw the line ILN, cutting the Arch KNF, in the point N, therefore set IL, be the Leagues you have unto the place whereunto you are bound, which is fortie one Leagues and a halfe, and the Rumb the distance KN, which is West, and by North, and three degrees unto the Northward, so likewise is the line AO, the number of Leagues you have run due South, which is sixtie eight Leagues and one mile, or three degrees and twenty five minutes, which being taken from fiftie degrees, the parallel from which you departed, leaves fortie six degrees and thirte five minutes for the Parallel you are in. Last of all, shall the line IO, be the Leagues that you have departed your first Meridian, which are fortie two leagues and one mile, Then take the middle latitude which is fortie eight degrees seventeen minutes and in the Table chap. 14 you shall find that thirteen Leagues o. mile, 92 parts, do answer unto a degree of Longitude in that Parallel, then setting one foot of your Compasses



point L draw the line LM, parallel unto GHF, then open your Compasses unto the distance of a hundred leagues, which are the Leagues the second ship did run, and set the foot of your Compasses in the Center A, and with the other make a mark in the line LM, which will be at M, then draw the line MA, which is the course of the second Ship, and the line FA, is the course of the first ship, then from F let a Perpendicular fall, being Perpendicular to the line GF, which is the line FK, then opening your Compasses unto the Radius of your Scale, set one foot in the Center F, and with the other draw the Quadrant HIK, likewise from F, the place of the first Ship, draw a line by the point M, the place of the second, cutting the Quadrant KHI, in I, so let IK, be the course that is betwixt them, that is, if you will saile from the first ship unto the second, you must saile North and by East, and one and fortie minutes to the Eastward, likewise let FM, be the distance that is betwixt them, which in this Demonstration is fortie Leagues, two miles, so shall BC, be the course of the first ship from the West Northward, which here is found to be thirtie degrees and one minut from the West Northward, or Northwest by West, and three degrees and fortie four minutes to the west ward. Lastly the Arch ED, is in the distance of the course that the second Ship made from the North Westward, which is found by this Demonstration to be North west and by North, and three degrees five minutes to the Westward.

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### CHAP. XIX.

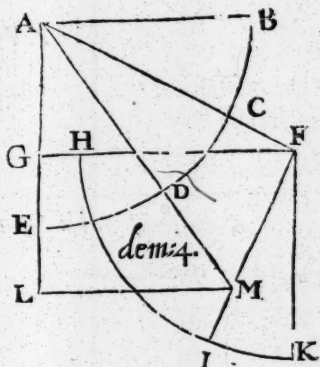
*Two Ships departing from one Parallell and Port in the Parallell of 47 deg. 56 min. the first in sayling 80 leag. betwixt the North and West, hath raised the Pole two degrees, I demand by what course the second ship must runne, and how much she shall alter in her first Meridian or longitude, to bring her selfe 40. leagues and two miles North and by East, and 41. minutes to the Eastward of the first ship?*

**I**N the fourth Demonstration draw the Quadrant ABCDE, then multiplie your two degrees you have altered your latitude by twentie and it maketh fourtie Leagues; which fourtie Leagues  
set

set upon the line A E L, from A unto G, then from the point G draw the line G F, parallel unto A B, then open your Compasses unto the distance of 80 Leagues, which are the Leagues your first Ship did runne, and place one foot of your Compasses in the Center A, and with the other make a marke in the line G F, which will be at the point F, then from the Center A unto the point F draw the line A F, representing the distance of the Course of the first Ship 80 leagues:

Then from F let fall a Perpendicular FK, and upon the Center F, with the Radius of the Scale draw the Arch H I K, Then in regard you must bring the second ship North and by East, and 41 minutes Eastward of the first ship, take 11 degrees 56 minutes from your Scale of Chords, and place them from K unto I, up-n the quadrant K I H. Then from F draw the line I F, and upon the line, F I, place the distance that you must bring the second ship from the first (which is forty leagues

and two miles) from F unto M. So is M the place of your second ship. Then from M draw the line ML parallel unto FG, cutting the line AGL in L, then draw the line MA, cutting the Quadrant BDE in D. So shall the Arch DE be the course that the second ship must run, to bring her self forty leagues and two miles North and by East, and 41 minutes East of the first ship. Then to know what you have altered the latitude, first take the distance LA and apply it unto the Scale of equall parts, and you shall find it to be 80 leagues, which is just 4 degrees, which you have altered your latitude, or Poles elevation: which 4 degrees added unto the latitude you departed from, it makes 51 degrees 56 min. for the latitude that your second Ship is in, then take the distance LM and apply it to the Scale, it gives 60 leagues; then open your Compasses unto the distance of the middle latitude, which is 49 deg. 56 min. of the Chord, and apply it unto the Table of longitudes, and it gives 12 leagues.





leagues, and 2 miles, and 62 parts, to alter one degree of longitude in that Parallel: Then set one foot of your Compasses in 12 leagues 2 miles, and 62 parts, and open the other to the beginning of the line, and with that distance measure the line *LM*, being 60 leagues, and you shall find that it is contained there in four times and two thirds, so the longitude is 4 degrees 40 minutes.

## CHAP. XXI.

*Of the Ebbing and Flowing of the Sea, and of the Tides, and how to find them in all places.*

*A generall Table for the Tides in all places.*

| The Moons age.                 |          |          | The Moons age.                 |          |          |
|--------------------------------|----------|----------|--------------------------------|----------|----------|
| Hours and minutes to be added. |          |          | Hours and minutes to be added. |          |          |
| Dates.                         | Degrees: | Minutes: | Dates.                         | Degrees: | Minutes: |
| 1                              | 0        | 48       | 16                             | 0        | 48       |
| 2                              | 1        | 36       | 17                             | 1        | 36       |
| 3                              | 2        | 24       | 18                             | 2        | 24       |
| 4                              | 3        | 21       | 19                             | 3        | 12       |
| 5                              | 4        | 0        | 20                             | 4        | 0        |
| 6                              | 4        | 48       | 21                             | 4        | 48       |
| 7                              | 5        | 36       | 22                             | 5        | 36       |
| 8                              | 6        | 24       | 23                             | 6        | 24       |
| 9                              | 7        | 12       | 24                             | 7        | 12       |
| 10                             | 8        | 0        | 25                             | 8        | 0        |
| 11                             | 8        | 48       | 26                             | 8        | 48       |
| 12                             | 9        | 36       | 27                             | 9        | 36       |
| 13                             | 10       | 24       | 28                             | 10       | 24       |
| 14                             | 11       | 12       | 29                             | 11       | 12       |
| 15                             | 0        | 0        | 30                             | 0        | 0        |



## The use of the Table of the Tides.

**F**irst it is to be understood, that by the swift motion of the first Mover, the Moon and all the rest of the Stars and Planets, are turned about the World in four and twenty hours, upon which swift motion of the Moon, the daily motions of the Sea, do depend, which motion of the Sea falleth not out alwaies at one hour, the reason thereof is, because of the swift motion of the Moon in regard she goeth almost thirteen degrees in four and twenty hours, and the Sun moveth scarce one degree, which gives every day twelve degrees, that the Moon cometh slower to any point in the Heaven than the Sun: which twelve degrees makes forty eight minutes of time for the difference of every full Sea, according unto the middle motion of the Moon, which difference is here set down in this Table for every day of the Moons age. Therefore if you would know the full Sea at any place in the World, first you must know at what hour it is full Sea at the new or full Moon; which hours and minutes keep in mind, then seek the age of the Moon as is before taught, and with the number of her age enter this Table, under the Title of the Moons age, and having found her age in the Table, against it you shall find the hours and minutes which are to be added unto the time that the Moon maketh full Sea in any place, and the whole number of hours and minutes is the time that the Moon maketh full Sea in that place upon the day desired. As for example, I desire to know the full Sea at London Bridge upon the 13 of July 1624. the age of the Moon being found as before, is eight daies, then in the Table I find eight daies, and against it 6 hours, and 24 minutes, which being added unto 3 hours, the full Sea upon the change day gives 9 a clock 24 minutes for the time at the full Sea upon the 13 day of July 1624.

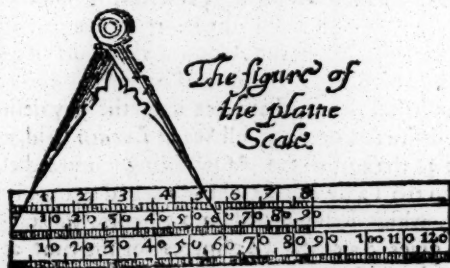
30  
THE  
SEAMANS  
GLASSE.

The Second Book.

VVherein is declared the Definition of the Sphear, a Description of the six great Circles, and also of the four lesser Circles, last of all, certain Questions Astronomically, performed by the said Scale.

CHAP. I.

*Of a Sphear, and the Circles thereof.*



*Sphear* according to the Description of *Theodosius*, is a certain solid Superficies, in whose middle is a Point, from which all lines drawn unto the Circumference are equall; which Point is called the Center of the Sphear, by which Center a right Line being drawn, and extending himself on either side unto that part of the Circumference whereupon the Sphear is turned, is called *Axis Sphaerae*, or the Axle-tree of the World,

*A Sphear*

A Sphear accidentally is divided into two parts, that is to say, in *Spharam rectam & Spharam obliquam.*

*Sphera recta*, or a right Sphear, is onely unto those that dwell under the *Equinoctiall*, *Quibus neuter Polorum magis altero eleuatur*: that is, to whom neither of the Poles of the World are seen, but lie hid in the *Horizon*.

*Sphera obliqua*, or an oblique Sphear, is unto those that inhabit on either side of the *Equinoctiall*, unto whom one of the Poles is ever seen, and the other hid under the *Horizon*.

The Circles whereupon the Sphear is composed are divided into two sorts: that is to say, in *Circulos majores & minores.*

*Circuli majores*, or the greater Circles, are those that divide the Sphear into two equall parts: and they are in number six, *viz.* the *Equinoctiall*, the middle of the *Zodiack*, or the *Ecliptique* line, the two *Columes*, the *Meridian*, and the *Horizon*.

*Minores vero Circuli*, or the lesser Circles, are such as divide the Sphear into two parts, unqually, and they are four in number; as the Tropick of *Cancer*, the Tropick of *Capricorn*, the Circle *Arctike* and the Circle *Antartike*.

## CHAP. II.

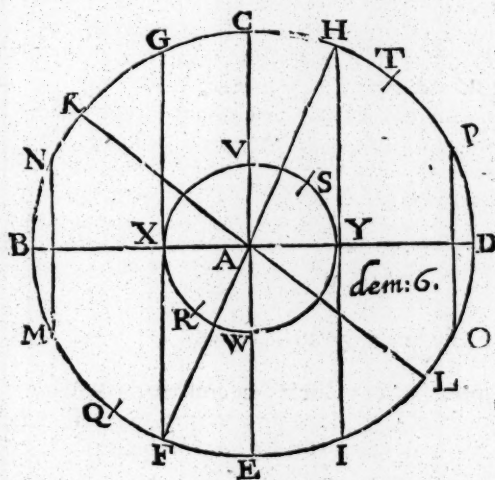
### Of the six greater Circles.

I. **T**HE *Equinoctiall* is a Circle that crosseth the Poles of the World at right Angles, and divideth the Sphear into two equall parts, and is called the *Equinoctiall*, because when the Sun cometh unto it, (which is twice in the year, *viz.* in *principio Arietis*, & *Libra*, that is, in *March* and *September*) the daies and nights are equal thoroughout the whole World, whereupon it is called *Equator diei & noctis*, the equall proportioner of the day and night artificiall: and in the figure is described by the line *CAE*.

II. The *Meridian* is a great Circle passing thorow the Poles of the World, and the Poles of the *Horizon*, or *Zenith* point over our heads; and is so called, because that in any time of the year, or in any

any place of the World, when the Sun (by the motion of the Heavens) cometh unto that Circle, it is noon, or twelve of the Clock. And it is to be understood, that all Towns and places that lie East and West one of another, have every one a severall Meridian: but all places that lie North and South one of another, have one and the same meridian. This Circle is declared in the figure following by the Circle BCDE.

III. The *Horizon* is a Circle dividing the superiour *Hemisphere* from the inferiour, whereupon it is called *Horizon*, that is to say, the bonds of sight, or the farthest distance that the eye can see, and there-



fore it is also called *Circulus hemisphari*. The *Horizons* are divided into 2 sorts, viz *Rectus* & *obliquus*, a Right and an oblique, or a declining *Horizon*: whereof those have a right *Horizon* which have the *Equinoctial* for their *Zenith*, & the Poles of the World in their *Horizon*: because the *Hori-*

zon (hiding both the Poles of the World) is a Circle supposed to be drawn by the Poles of the World, dividing the *Equinoctial* at right Angles, as in the figure following you may plainly see. First imagining the Circle X V Y VV to be the earth, and those that inhabit at the Point V have the line BD for their *Horizon*, cutting the *Equinoctial* CAE at right Angles in A, and therefore is called *Horizon rectus* & *Sphæra recta*, a right *Horizon*, and a right sphere.

*Sphaer.* Those have an oblique *Sphere*, or an oblique *Horizon*, to whom one of the Poles are visuall, or elevated above the *Horizon*, and have the other hid under the *Horizon*, and in regard such a *Horizon* doth crosse the *Equinoctiall* at oblique Angles, it is called *Horizon obliquus*, or a declining *Horizon*, as for example, Those that inhabit at the point *S* have *T* for their *Zenith*, and *K A L* for their *Horizon*, dividing the *Equinoctiall* *C A E* at oblique Angles, making the Angle contained betwixt the *Horizon* *A K* and the *Equinoctiall* *A C*, an Angle of thirty eight degrees, and twenty eight minutes, and the Angle contained betwixt the *Horizon* *A L* and the Pole *A D*, an Angle of 51. degrees 32 minutes, which is the elevation of the Pole for those that inhabit at *S*, as those at *London*, these and all other have an oblique *Sphere*, except they inhabit just under the *Equinoctiall* Circle, unto whom onely doth a right *Sphere* belong.

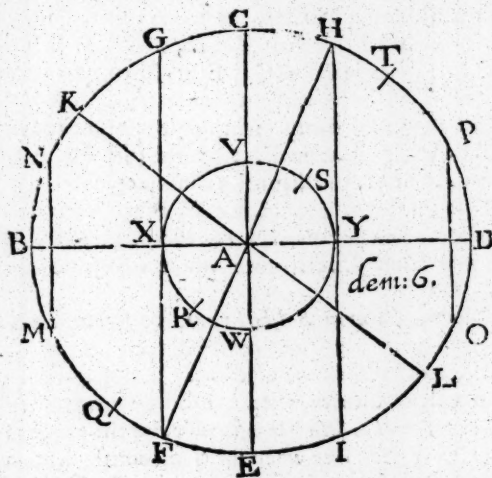
IV. The two Colures, *Colurus Solstitiorum*, or the Summer Colure, is a Circle passing by the Poles of the World, and by the Poles of the Ecliptick, and by the head of *Cancer* and *Capricorn*, whereupon, the first scruple of *Cancer*, where the Colure crosseth the Ecliptick Line, is called *Punctus solstitia estivalis*, or the point of the Summer Solstice: to which place when the Sun cometh, he can approach no nearer unto our *Zenith*, but returneth unto the *Equator* again. *Arctus vero Coluri*, The Ark of the Colure contained betwixt the Summer Solstice and the *Equator*, is called the greatest declination of the Sun, which *Ptolomy* found to be 23 degrees, 31 minutes: but by the observation of *Copernicus* it was found to vary, for he found the declination sometimes to be 23 degrees 52 minutes, and in the proceſſe of time to be but 23 degrees 28 minutes. And in these our daies (by the observation of *Ticho de Brahe*, and that late famous Mathematician, *Mr. Edward Right*) it is found distant from the *Equinoctiall* 23 degrees, 31 minutes, 30 seconds.

V. The other Colure passeth by the Poles of the World, & by the first point of *Aries* and *Libra*, whereupon it is called *Colurus distinguens Equinoxia*. These two Colures do crosse each other at right Angles in the Poles of the world, whereupon these verses were made.

Hæc duo Solstitia faciunt *Cancer Capricornus*,  
Sed noctes æquant *Aries & Libra* diebus.

VI. The Zodiack is another of the greatet Circles, dividing the *Equinoſſiall* into two equall parts, by the head of *Aries* and *Libra*, the one half of it doth decline unto the North, and the o-

ther into the South, the grea-  
teſt of which  
declinations is  
23 degrees, 31  
minutes, and 30  
seconds. Note  
alſo, this Circle  
is divided into  
twelve equall  
parts, which  
parts are attri-  
buted unto the  
twelve Signes,  
*Aries*, *Taurus*,  
*Gemini*, *Cancer*  
*Leo*, *Virgo*, *Li-  
bra*, *Scorpio*,  
*Sagittarius*, *Ca-  
pricornus*, *A-*



*quarini*, and *Pisces*. And every one of these Signes are divided into 30 equall parts, which are called degrees, so the whole Zodiack containeth one hundred and sixty degrees. Likewise every degree is divided into sixty equall parts, which parts are called minutes, and are in number 21600 minutes, and as 21600 minutes is the whole Circumference of the Heavens, so is 21600 miles the whole circuit of the Earth.



## CHAP. III.

## Of the four lesser Circles.

**T**He Sun having ascended unto his highest Solstitial Point doth describe a Circle, which is the nearest that he can approach unto the North Pole, whereupon it is called *Circulus Solstitii æstivalis*, the Circle of the Summer Solstice, or the Tropick of *Cancer*, and is noted in the figure before, by the line H Y I.

The Sun also approaching unto the first scruple of *Capricornus*, or the Winter Solstice, describeth another Circle, which is the utmost bounds that the Sun can depart from the Equinoctiall Line towards the Antartike Pole, whereupon it is called *Circulus solstitii hyemalis*, *sive Tropicus hyemalis*, *vel Capricorni*: the Circle of the Winter Solstice, the Winter Tropick, or the Tropick of *Capricorn*, and is described in the figure by the line G X F.

So much as the Ecliptick declineth from the Equinoctiall, so much doth the Poles of the Ecliptick decline from the Poles of the VWorld, whereupon the Pole of the Ecliptick, which is by the North Pole of the VWorld, describeth a certain Circle as it passeth about the Pole of the VWorld, being just so far from the Pole as the Tropick of *Cancer* is from the Equator, and it is the third of the lesser Circles, and is called *Circulus Arcticus*, or the Circle of the North Pole, and is described in the *Diagram*, in the second Chapter by the line P O.

The fourth and last of the lesser Circles is described in like manner, by the other Pole of the Ecliptick, about the South Pole of the world, and therefore called *Circulus Antarticus*, the Antartick Circle, or the Circle of the Antartick or South Pole, and is demonstrated in the former figure, by the line N M.

## CHAP. IV.

*Definitions of some peculiar terms fit to be known by such as intend to practise the Art of Navigation or Astronomy.*

**T**He Zenith is an imaginary point in the Heavens over our heads, making right Angles with the Horizon, as the Equinoctiall maketh with the Pole.

The *Nadir* is a prick in the heavens under our feet, making right Angles with the Horizon under the earth, as the Zenith doth above, and therefore is opposite unto the Zenith.

The declination of the Sun is the Ark of a Circle contained betwixt the place of the Sun in the Ecliptick, and the Equinoctiall, making right Angles with the Equinoctiall. But the declination of a Star is the Ark of a Circle let fall from the Center of a Star, perpendicularly unto the Equinoctiall.

The Latitude is the Ark of a Circle contained betwixt the Center of any Star, and the Ecliptick Line, making right Angles with the Ecliptick, and counted either Northward, or Southward, according to the situation of the Star, whether it be nearer unto the North or South Pole of the Ecliptick.

The Latitude of a Town or Countrey, is the height of the Pole above the Horizon, or the distance betwixt the Zenith and the Equinoctiall.

The Longitude of a Star is that part of the Ecliptick which is contained betwixt the Stars place in the Ecliptick, and the beginning of *Aries*, counting them from *Aries* according to the succession or order of the signes.

The Longitude of a Town or Countrey are the number of degrees, which are contained in the Equinoctiall, betwixt the Meridian that passeth over the Isles of *Azores*, (from whence the beginning of longitude is accounted) East wards, and the Meridian that passeth over the Town or Country desired.

The Altitude of the Sun or Star is the Arch of a Circle, contained betwixt the Center of the Sun, or any Star, and the Horizon.

The

The Amplitude is that part of the Horizon which is betwixt the true East or West points, and the point of the Compasse that the Sun or any Star doth rise or set upon.

Azimuth's are Circles, which meet together in the Zenith, and crosse the Horizon at right Angles, and serve to find the point of the Compasse, which the Sun is upon at any hour of the day, or the Azimuth of the Sun or Star, is a part of the Horizon contained betwixt the true East or West point, and that Azimuth which passeth by the Center of the same Star to the Horizon.

The right ascension of a Star is that part of the Equinoctiall that riseth or setteth with the Star, in a right Sphere: or in an oblique Sphere, it is that portion of the Equinoctiall, contained betwixt the beginning of *Aries*, and that place of the Equinoctiall, which passeth by the Meridian with the Center of the Star.

The oblique ascension is a part of the Equinoctiall, contained betwixt the beginning of *Aries*, and that part of the Equinoctiall that riseth with the Center of a Star, in an oblique Sphere.

The difference ascensionall, is the difference betwixt the right and oblique ascension: or it is the number of degrees contained betwixt that place of the Equinoctiall that riseth with the Center of a Star, and that place of the Equinoctiall that cometh unto the Meridian, with the Center of the same Star.

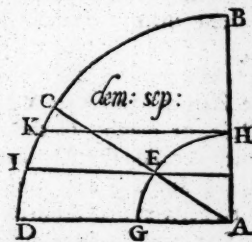
*Almicanters* are Circles drawn parallel unto the Horizon, one over another, untill you come unto the Zenith: these are Circles that do measure the elevation of the Pole, or height of the Sun, Moon, or Stars above the Horizon, which is called the Almicanter of the Sun, Moon, or Star: the Ark of the Sun or Stars Almicanter, is a portion of an Azimuth contained betwixt that Almicanter which passeth thorow the Center of the Star, and the Horizon.

# QUESTIONS ASTRONOMICAL, performed by the plain Scale.

## CHAP. V.

*The true place of the Sun being given, to find his declination.  
The Sun being in the head of Taurus, his declination is desired.*

**B**Y the seventh Demonstration, draw the line *A D*, then upon the Center *A* raise the Perpendicular *A B*, then opening your Compasses to the Radius of your Scale, place one foot in the Center *A*, and with the other draw the Quadrant *B C D*, then opening your Compasses unto the greatest declination of the Sun, place it upon the Quadrant, from *D* unto *K*, then from the point *K* draw the line *K H*, parallel to *D A*, cutting the line *A B* in *H*, then with the distance *A H* draw the small Quadrant



*GEH*, and in regard the Sun is in the head of *Taurus*, which is 30 degrees from the beginning of *Aries*, let *AD* be the Equator, and *D* the beginning of *Aries*, *DC* 30 degrees, or longitude of the Sun, then from the point *C* draw the line *CA*, cutting the Quadrant *GEH* in *E*, then from *E* draw the line *E I* parallel to *AD*, cut-

ting the Quadrant *B C D* in *I*, so shall the Arch *ID* be the declination of the Sun desired, which in this demonstration is found to be eleven degrees, and thirty one minutes.

## CHAP. VI.

*The declination of the Sun, and quarter of the Ecliptick that he possesseth, being given, it is desired to find his true place.*

*The Declination is 10 deg. 31 min. the first quarter that he possesseth, is betwixt the head of Aries and Cancer.*

**F**irst, by the seventh Demonstration, draw the Quadrant  $A B C D$ , as is taught in the former Chapter, then set the greatest declination of the Sun upon the Chord from  $D$  unto  $K$ , which is 23 deg. and 31 min. then from  $K$  draw the line  $K H$  parallel unto the Equator  $D A$ , cutting the line  $B A$  in the point  $H$ . So shall  $H A$  be the sign of the Suns greatest declination, then with the distance  $A H$  draw the Quadrant  $G E H$ , then from  $D$  upon the Quadrant  $D B C$  set the declination of the Sun, which is 11 degrees 31 minutes from  $D$  unto  $I$ , then draw the line  $I E$  parallel unto  $A D$ , cutting the Quadrant  $G E H$  in  $E$ . Then from the Center  $A$  by the point  $E$ , draw the line  $A E C$ , cutting the Quadrant  $B C D$  in  $C$ . So shall the Ark  $C D$  be the distance of the sun from the head of Aries, which is here found to be just 30 degrees, which is in the beginning of Taurus.

## CHAP. VII.

*By the elevation of the Pole, and declination of the sun, to find the amplitude of the sun, or his distance of rising, or setting from the true East or West point.*

*The elevation of the Pole is 41 deg. 32 min. the declination of the sun is 14 deg. 52 min. North.*

**B**y the eight Demonstration, first draw the line  $B D$ , then upon the Center  $A$  draw the Circle  $B C D E$ , then from  $A$  raise the Perpendicular  $C A E$ , then is your Circle divided into four equal parts: then suppose the elevation of the Pole to be





## CHAP. VIII.

*By the Amplitude of the Sun, to find the variation of the Compasse.*

**H**AVING found the Amplitude of the Sun by the last Chapter, first observe with a Compasse, or rather with a Semicircle, upon what degree and minute the Sun riseth or setteth, beginning to reckon from the East or West, and ending at the North or South at 90 degrees: and when you have diligently observed the Magneticall rising or setting, by the Semicircle, or by some other like fixing Instrument: and also the true Amplitude found, as is declared in the last Chapter, the difference of these two Amplitudes, is the variation of the Compasse: But when the Sun riseth upon the same Degree of the Compasse, as is found by the Scale, the variation is nothing, but the Needle pointeth directly unto the Poles of the World, which by *M. Mullinix* was affirmed to be at the Westernmost part of *S. Michaels*, one of the Islands of the *Azores*, from whence he will have the Longitude reckoned. Secondly, when the Sun is in the Equinoctial Circle, where he hath no Amplitude, look what distance the Compasse maketh the Sun to rise from the East or West of the Compasse, the same distance is the Compasses variation, from the North or South. Thirdly, if the Sun rise more to the South of the Compasse, or setteth more to the North of the Compasse, than is shewed by the Scale, the difference betwixt the Amplitude given by the Scale, and the Amplitude given by the Needle, is the variation of the Compasse from the North Westward. Fourthly, if the Compasse sheweth the Sun to rise more Northward, or set more Southward, than is shewed by the Scale, the difference is the variation of the Compasse, from the North Eastward. Fifthly, if the Scale shew the Amplitude of the Sun rising Southerly, and the Compasse shew it to be Northerly, adde both the Amplitudes together, and they shew you the variation Westernly.

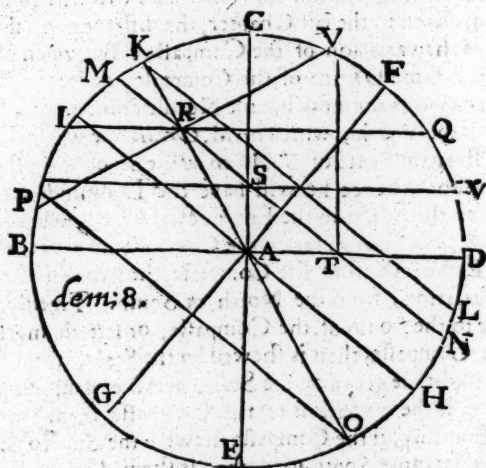
CHAP.

## CHAR. IX.

*The place of the ſun being given, to find his declination, by a whole Circle.*

*The ſuns place is the tenth degree of Taurus.*

**A** According unto the eighth Demonſtration, firſt draw the Circle B C D E, then draw the Horizon B A D, and then the Equinoctial I A H, as is before taught: and then the Tropick of *Cancer* K L, twenty three degrees and a half from the Equinoctial: then draw the Tropick of *Capricorn* P O,



of like diſtance from the Equinoctial, and after from K to O draw the Ecliptick line K A O. And when you have thus laid down the Sphere, ſuppoſe the Sun to be in the tenth degree of *Taurus*, at which time his declination is deſired. And in regard the Sun is more near unto the Tropical point *Cancer*, than unto *Capricorn*; firſt find how many

many degrees he is from the Tropick of *Cancer*, and you shall find him to be 50 degrees; therefore take with your Compasses 50 degrees from the Chord, and apply it from the Tropical point *Cancer* at *K*, unto *V*, upon one side, and unto *P* on the other side: then draw the Line *V P*, cutting the Ecliptick *K O* in the point *R*, then from *R* draw the Line *M R N* parallel unto the Equinoctial *I A H*, and cutting the Quadrant *B C* in the point *M*. So shall the arke *M I* be the declination of the Sun desired, which being applyed unto your Scale, gives you 14 deg. and 52 minutes.

CHAP. X.

*The elevation of the Pole, and declination of the sun given, to find his height in the vertical Circle.*

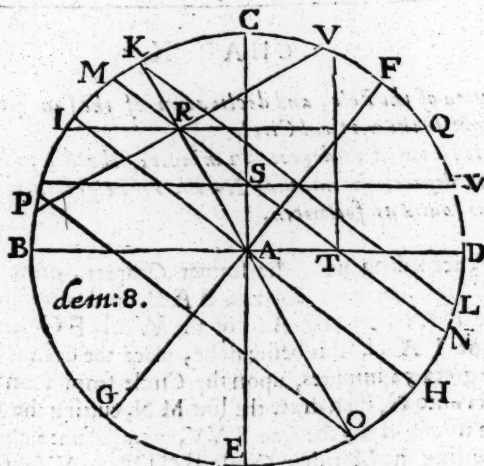
*The Pole is elevated 51 degrees 32 minutes, the declination of the sun is 14 degrees 52 minutes North, his height in the Vertical Circle is found as followeth.*

**F**irst, according unto the former Chapter, draw the Circle *B C D E*, then the Horizon *B A D*, and after the vertical line *C A E*, then the Axis of the World *F G*, and likewise the Equator *I A H*, this being done, place the declination of the Sun 14 degrees 52 minutes, upon the Circle from *I* unto *M*, and also from *H* unto *N*, then draw the line *M N*, cutting the line *C A E* in *S*, then from *S* draw the line *S V V*, parallel unto the Horizon *B A D*, cutting the Meridian Circle *B C D E* in *V V*: so shall the distance *D V V* be the height of the Sun in the vertical Circle, for the time demanded, which by this proposition is found to be 19 degrees and 8 minutes.

## CHAP. XI.

*The elevation of the Pole, and the Amplitude of the sun, being given, to find the declination,*

*The elevation of the Pole is 51 degrees 32 minutes, the suns amplitude is 24 degrees 21 minutes, the declination is found as followeth.*



**F**irst, as in the eight demonstration, upon the Center A, draw the Circle B C D E, then draw the Line B A D, representing the Horizon: dividing the circle into two equall parts then draw the Line C A E, perpendicular to B A D, representing the East and VVest points of the Compass, then placing the elevation of the Pole 51 degrees and 32 minutes, from D unto F, from F, by the center A, draw the Line F A G, which let be the Pole or Axletree of the world, then from B unto I, and from D unto H,

(et

set the complement of the Poles elevation: which shall represent the Equinoctiall, in regard it maketh right Angles with the Pole of the world, in the center A. Then from C unto V place the amplitude of the Sun, which is 24 degrees and 21 minutes: then from V let fall the perpendicular VT, cutting the Horizon BAD in the point T, then from the point T, draw the Line MTN parallel unto the Equinoctiall IAH, and cutting the Circle BCDE in the points, M and N, so shall the distance, M, or H N, be the declination of the Sun, which was desired: which being applied unto your Scale, gives you fourteen degrees and fifty two minutes.

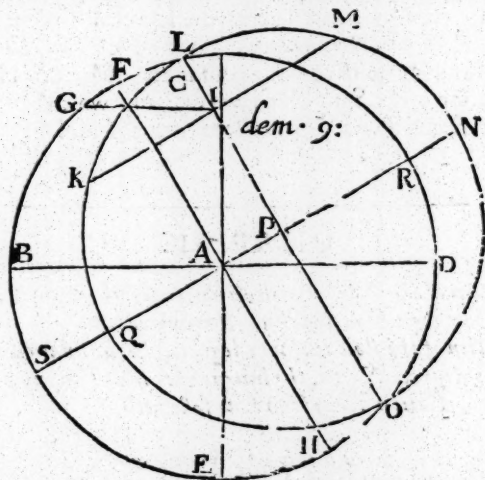
## CHAP. XII.

*The elevation of the Pole, the declination of the Sun, and hour of the day being given, to find the Almicanter.*

*The elevation of the Pole is thirty degrees, the declination of the Sun is twenty degrees North, the hour is nine in the morning, at which time the Almicanter is found, as followeth.*

**B**Y the ninth demonstration, first upon the Center A, draw the Circle BCDE, then draw the line BD for the Horizon, then place your Poles elevation, which is thirty degrees, upon the Circle: from D unto R, then from R by the center A, draw the Line RAS, representing the Axis of the World, then from B unto F place the complement of the Poles elevation, which is 60 degrees, and from the point F, by the Center A, draw the line FAH, representing the Equinoctial line, and then let the declination of the Sun from F unto L, and from L draw the Line LPO parallel unto the Equator FAH, cutting the Axis of the World in the point P, then set one foot of your Compasses in the point P, and extend the other either unto L or unto O, and with the same distance of your Compasses, upon the Center P, draw the circle LNOQ, which is called the hour circle: so shall L be the point of twelve a clock at noon, N the place of six a clock after noon, O the place of twelve a clock or midnight, and Q the place of six a clock  
in

in the morning: Every one of the four quarters muſt be divided into ſix equall parts, or hours, making the whole Circle to contain twenty four parts, repreſenting the twenty four hours of the day and night, then in regard the hour of the day was nine of the clock, which is three hours before noon, take three of thoſe twenty four



hours, and place them upon the circle L N O Q, from the Meridian point L unto K, the nine a clock point in the morning, and unto M the point of three a clock after noon, then draw the line M K, cutting the parallel of the Sun L O in the point I, then from I draw the line I G parallel unto the Horizon B A D, which ſhall cut the Meridian Circle B C D E in the point G, ſo ſhall the diſtance of G and B be the Almicanter the Sun, which was deſired, which in this demonſtration is found to be forty eight degrees and eighteen minutes.



## CHAP. XIII

*The elevation of the Pole, the Almicanter, and declination of the Sunne, being given, to finde the houre of the day.*

*The elevation of the Pole is thirty degrees, the declination of the Sun, is twentie degrees, the Almicanter of the Sun, is fortie eight degrees, and eightene minutes, the houre of the day is found as followeth.*

**F**irst, as in the ninth demonstration, upon the Center A, draw the Circle B C D E, then draw the Diameter B D, representing the Horizon, then from D unto R, set 30 degrees, the elevation of the Pole, then from R unto the point A, draw the line R A S, representing the Pole of the World; then draw the line F A H, crossing the Pole in A, at right Angles, cutting the Meridian circle in F, then from F, set twenty degrees, the declination of the Sun unto L, and then from the point L, draw the line L P O, representing the parallell of the Sun, and cutting the Pole of the World in P, then placing one foot of your Compasses in B, extend the other unto L, with which distance of your Compasses, draw the hour Circle L N O Q, then from the Horizon at B, place the Suns Almicanter: (which is fortie eight degrees, and eighteen minutes,) upon the Quadrant B G L, from B unto G, then from the point G, draw the line G J, parallel unto the Horizon B A D, cutting the Line L O, in I, then from the point I, draw the line K I M, parallel to the Pole of the World Q A N, cutting the Circle L N O, in M, then let L N, be divided into six houres, whereof L M, are there: whereupon I conclude, that is is three houres from noon, that is, at nine a clock in the morning, or three in the after noon.

## CHAP. XIV.

*The Latitude of the place, the Declination of the Sun, and the Altitude of the Sun being given, to finde the Hour of the day : By a new way differing from that in the former Chapter.*

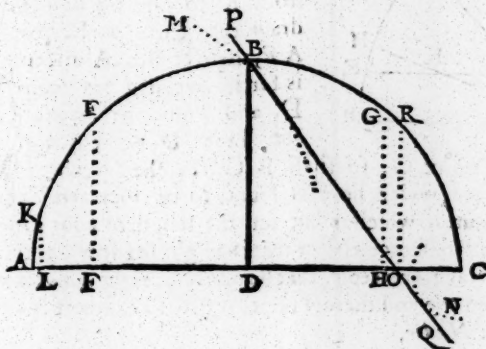
|                              | deg. | min. |               | deg.             | m. |
|------------------------------|------|------|---------------|------------------|----|
| The Suns Altitude is         | 48   | 18   | } its Comple. | } 60             | 00 |
| The Latitude of the place is | 30   | 00   |               |                  |    |
| The Suns declination is      | 20   | 00   |               |                  |    |
|                              |      |      |               | 70               | 00 |
|                              |      |      |               | Sum 130 00       |    |
|                              |      |      |               | difference 10 00 |    |

*The Complement of any arch lesse then 90 degrees, is so much as the arch wants of 90 degrees, as the Complement of 20 degrees is 70 degrees, &c.*

**F**irst, finde the sum and difference of the Complement of the Suns declination, and the Complement of the Latitude, as above is done, where the sum is 130 deg. and the difference 10 deg. Then your Compasses being opened to the *Radius* of your line of Chords: describe the Semicircle *ABC*, and divide it into two Quadrants by the perpendicular *BD*, then out of your line of Chords; take 48 deg. 18 min. the Suns Altitude, and set it from *B* to *E*, and draw *EF* parallel to *BD*: Then from your line of Chords take 130 deg. the sum, and set it from *A* to *G*, (or its Complement to 180 deg. which is 50 deg. from *C* to *G*) and draw the line *GH* also parallel to *BD*. Again, out of your line of Chords, take 10 deg. (which is the difference) and set that distance from *A* to *K*, and draw *KL* parallel to *EF* or *BD*.

This done, take with your Compasses the distance from *F* to *H*, and setting one foot in *A*, with the other describe the Arch *MP*, likewise take the distance from *F* to *L*, and setting one foot in *C*, with

with the other describe the arch N Q. Lastly draw the straight line P Q, which only touching the two former arkes will cut the line A C in O, Upon the point O, therefore, erect the perpendicular O R,



cutting the Semicircle in R, so will CR being measured upon your line of Chords, give you the degrees of the Sun from the South part of the Meridian, which here you will finde to be 45 degrees, which make 3 hours, allowing 15 degrees for an hour, for 15 degrees make one hour, and one degree makes 4 minuts of an hour, so that it is either 9 of the clock in the morning, or 3 in the afternoon.

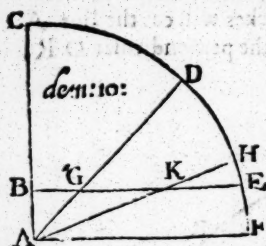
# CHAP. XV.

The Almicanter, or height of the Sun being given, to finde the length of the right shadow.

The Almicanter is 45 degrees.

According unto the tenth Diagram, draw the line AF, and upon the center A, raise the perpendicular AC, then upon the center A, draw the Quadrant CDF, then suppose the height

height of your *Gnomon*, or substance yielding shadow be the Line,



AB, which is to be divided into 12 equall parts, which *Gnomon*, I have here made just 12 degrees of the equall Leaguers of the Scale, then from B, to the top of the *Gnomon* draw the Line BE, parallel unto AF, then set the Almicanter which is fortie five degrees from F, unto D, and from the point D, draw the Line DA, cutting the Line

BE in the point G, so shall BG, be the length of the right shadow desired, which here is found to be fourteen degrees and eighteen minutes, which is but just the length of your *Gnomon*, and  $\frac{2}{3}$  and  $\frac{1}{3}$  of a twelve over: Note that the right shadow, is the shadow of any pole, staffe, or steeple, that standeth at right Angles with the Horizon, the one end thereof respecting the Zenith of the place, and the other the *Nadir*.

## CHAP. XVI.

The Almicanter, or height of the Sun being given, to finde the length of the contrary shadow.

The Almicanter given is 70 deg.

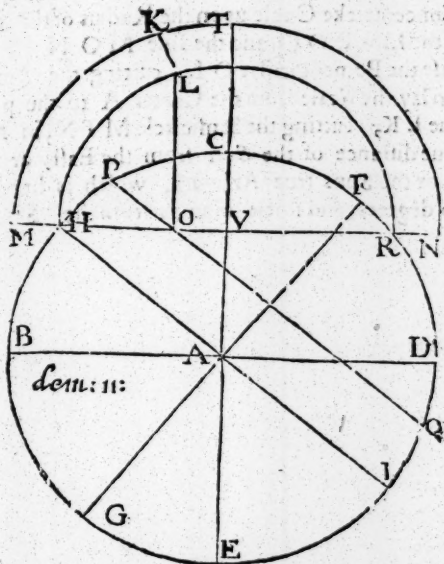
**B**Y the verse or contrary shadow, is understood the length of any shadow, that is made by a staffe or *Gnomon*, standing against any perpendicular wall, in such a manner that it may be parallel unto the Horizon, the length of the contrary shadow, doth increase as the Sun riseth in height, whereas contrariwise the right shadow doth increase in length, as the Sun doth increase in height: the way to finde the verse shadow is as followeth. First, draw your Quadrant as is taught in the last Chapter, wherein let AB, be the length of the *Gnomon*, likewise from B, draw the line BE, parallel unto AF, as before, then set your Almicanter from C, upon the Quadrant which is given to be seventie degrees and

it will extend from C unto H, then from the point H draw the line H A, cutting the line B E, in the point K, so shall K B, be the length of the contrary shadow, which here is found to be thirtie four degrees and eight minutes, or twice so long as your Gnomon, and  $\frac{2}{3}$  about  $\frac{1}{2}$  part of a twelfth more.

CHAP. XVII.

*The latitude of the place, the Almicanter, and declination of the Sun being given, to find the Azimuth.*

*The latitude of the place is fiftie one degrees, thirtie minutes, the declination of the Sun twenty degrees North, the Almicanter thirtie eight degrees thirtie minutes, the true Azimuth of the Sun is desired.*



**F**irst as in the eleventh Demonstration upon the Center A; draw the Circle B C D E, then draw the Diameter R A D.

and from D unto F, set the Elevation of the Pole, which is one and fiftie degrees, and thirtie minutes, whose complement is eight and thirtie degrees and thirtie minutes, which must be placed from B unto H, then from H, draw the line H A L, representing the Equinoctial line, and from F, draw the line F A G, representing the Pole of the World, then from H unto P, and from I unto Q, set the declination of the Sun, which is twentie-degrees, and by these two points draw the line P Q, for the Parallel of the Suns declination; then upon the Circle from B unto H, set the Suns Almicanter, thirtie eight degrees, and thirtie minutes, then from H, draw the line H R, parallel unto the Horizon cutting the Suns parallel P O Q, in O, then draw the Line T V A E Perpendicular unto the line B A D, in the Center A, and cutting the line H V R, in V, then setting one foot of your Compasses in the point V, extend the other unto R, and with the same distance draw the Semicircle H L R, then draw the Concentricke Circle upon the Radius of the Scale M T N, and where the Line P O Q, and the line M O N do meet in the point V, raise the Perpendicular O L, cutting the Semicircle H L R in L, then lay the Scale from the Center A to the point L, and draw the line L K, cutting the Semicircle M T N, in K, so shall M K, be the true distance of the Sun from the East, or West point Southward, or the Suns true Azimuth, which is here found to be seventie two degrees, and fortie minutes from the South part of the Meridian.

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CHAP.



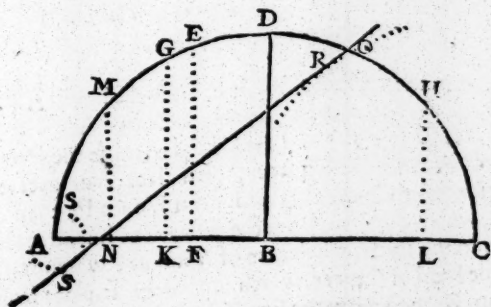
CHAP. XVIII.

*The Latitude of the place, the Declination of the Sun, and the Altitude of the Sun being given to finde the Azimuth : By a new way differing from that in the former Chapter.*

|                              | deg. | min. S. |                 | deg.             | m. |    |
|------------------------------|------|---------|-----------------|------------------|----|----|
| The Suns Declination is      | 20   | 00      | } its Comple. } | {                |    |    |
| The Latitude of the place is | 51   | 30      |                 |                  | 38 | 30 |
| The Suns Altitude is         | 12   | 00      |                 |                  | 78 | 00 |
|                              |      |         |                 | <u>Sum 116</u>   |    |    |
|                              |      |         |                 | difference 39 30 |    |    |

**H**aving found the sum and the difference of the complement of the Suns Altitude, and the complement of the Latitude as above is expressed where you finde the Sum of them to be 116 deg. 30 min. and their difference 39 deg. 30 min.

These things being premised, with your Compasses being opened to 60 deg. of your line of Chords, describe the Semicircle A D C, and



upon the Center B, erect the perpendicular B D, then First, out of your line of Chords take 20 deg. the Suns declination, and set that

distance from D to E, (if the Sun have South declination (as in this Example it hath) or from D to O, if the Sun have North declination) and draw the line E F parallel to D B.

Secondly, take 116 deg. 30 min. the sum out of your line of Chords, and set it from C to G, and draw the line G K parallel D to B,

Thirdly take 39 deg. 30 min. the difference, out of your line of Chords, and set it from C to H, and draw the line H L parallel also to B D.

Fourthly Take in your compasses the distance from F to K, and setting one foot in A, with the other describe the arch S.

Fifthly, Take the distance from F, to L, and setting one foot in C, with the other describe the arch R.

Sixthly, Lay a ruler, that it may only touch these two arches, S, and R, and by it draw a line as S R, cutting the line A C in N.

Lastly, upon the point N, erect the perpendicular N M, then the distance A M, measured upon your Line of Chords, is the Azimuth from the South part of the Meridian, which in this example will be found to be 34 deg. M C the Azimuth from the North 146 deg. And M D, the Azimuth from the East or West, 56 deg.

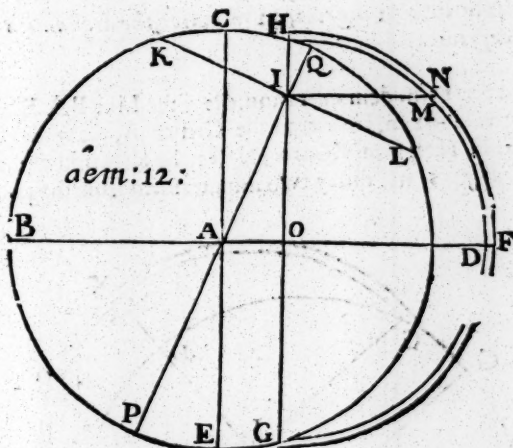
## CHAP. XIX,

*The place of the Sun being given, to find the right ascension, Suppose the Sun be in the twentieth degree of Taurus, his right ascension is found as followeth.*

**F**irst, as in the 12 demonstration, draw the line B A F, for the Pole of the World, the upon the Center A draw the Circle B C D E, then from the Center A, raise the Perpendicular C A E, for the Equator, then place your greatest declination from C unto Q, and from E unto P; then draw the line Q A P, which doth represent the Eccipticke line, then in regard the Sunne is in the twentieth degree of *Taurus*, which is forty degrees, from the head of *Cancer*, which forty degrees, place from Q unto L, and unto K, then draw the line K L, cutting the Eccipticke in I, then from the point I draw the line H I, parallel unto C A E, cut-

ing

ting the Pole of the World in *O* then set one foot of your Compasses in *O*, and extend the other unto *G*, with which distance draw the Semicircle *H D G*, then opening your Compasses unto the Radius of the Scale, and upon the Center *O*, likewise draw the Circle *H N F G*,



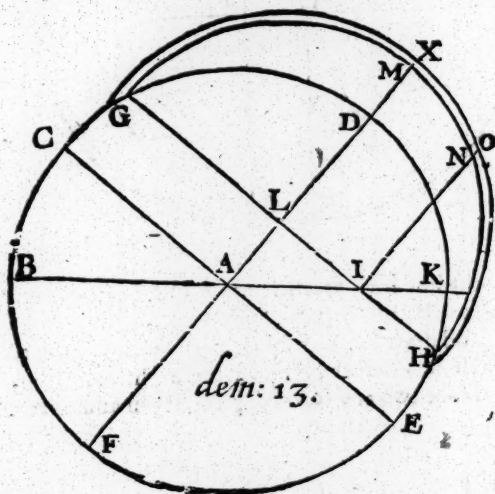
then draw the line *I M*, parallel unto *A O D*, cutting the Semicircle *H M D G*, in *M*, then lay your Scale from the Center *O*, unto the point *M*, and draw the Line *N M*, cutting the Concentricke Circle in *N*, so shall the distance *N F*, be the right ascension, which is here found to be two and fortie degrees, seven and twentie minutes.

## CHAP. XX.

*The elevation of the Pole, and declination of the Sunne given, to finde the difference of the ascensions.*

*The Poles elevation is 51 degrees, 32 minutes, the declination of the Sun is 21. degrees.*

**F**irst, as in the 13th. demonstration, draw the Line B A K, representing the Horizon, then upon the Center A, draw the Circle B C D E F, Then from K unto D, set the elevation of the Pole which is 51 degrees, and thirty two minutes: then from the point D,



by the Center A, draw the Line D A F, representing the Pole of the World, then from B unto C, set the Complement of the Poles elevation which is thirty eight degrees, and 28 minutes: then from C by the center A, draw the line C A E, representing the Equinoctial

no<sup>ti</sup>all Line ; then from Cunto G, and likewise from Bunto H, for the declination of the Sunne, which is 21 degrees, then from G unto H, draw the parallel of the Sunnes declination, cutting the Pole of the world in L, and the Horizon in I, then set one foote of your Compasses in the point L, and extend the other unto G, then with that distance of your Compasses draw the Semicircle G M N H, then opening your Compasses unto the Radius of your Scale, upon the same Center draw the Concentricke Circle, G X O H, then from I, where the declination of the Sunne doth cut the Horizon, draw the Line I N, parallell unto the Pole of the World A M, cutting the Circle G M H in N, then lay your Ruler from the point I unto the point N, and so draw the line N O, cutting the Concentricke Circle G X O H, in O, so shall the distance of O and X, be the difference of the ascensions, which is here found to be eight and twentie degrees, and foure and fiftie minutes.

# CHAP. XXI.

*The right ascension of the Sun or of a Star being given, together with the difference of their ascension, to finde the oblique ascension or descension.*

*The Sun is in the 4th. degree of Sagittarius, his right ascension is 242 degrees, or 16 hours 8 minutes, the difference of ascension is 1 hour 53 min. or 28 deg. 28 min. the oblique ascension or descension is required.*

**T**He right ascension of any point of the Heavens being known, the difference of the ascension is either to be added therunto, or else to be subtracted from it, according as the Starre is situate in the Northern or Southerne Signes: As for example, if the Sunne be in any of these sixe Signes, *Aries, Taurus, Gemini, Cancer, Leo, or Virgo*, then the difference of the ascensions is to be subtracted from the right ascension, and the remainder is the oblique ascension. Suppose therefore the Sunne to be in the fourth degree of *Gemini*, where the right ascension is found to be foure houres, and 8 minutes, or 62 degrees, and the difference of ascension where the Pole is elevated 51 degrees, is found to be one hour 53 minutes, otherwise 28 degrees 50

minutes, which being taken from the right ascension, leaves two houres and 16 minutes, or 23 degrees and 42 minutes, which is the oblique ascension of the Sunne in the fourth degree of *Gemini*.

But if the Sun be upon the South side of the Equinoctiall, either in *Libra*, *Scorpio*, *Sagitarus*, *Capricornus*, *Aquarius*, or *Pisces*, then the difference of the ascensions is to bee added unto the right ascension, and the Product will be the oblique ascension. Suppose the fourth degree of *Sagitarus* is given, for which Sign and degree the oblique ascension of the Sun is desired, his right ascension being then found to be 242 degrees, or 16 hours 8. min. the difference of the ascensions is one hour, 53 minutes, or 28 degrees, 18 minutes: which being added unto the right ascension, makes 18 hours, and one minute; or in degrees 270 degrees, and 18. minutes: which is the oblique ascension of the Sunne, when he is in the fourth degree of *Sagitarus*. And if you would finde the oblique descension, you must adde the difference of the ascensions unto the right ascension, when the Sunne is in these six Signes. *Aries*, *Taurus*, *Gemini*, *Cancer*, *Leo*, *Virgo*: and contrariwise, when the Sunn is in the other six Signes, you must substract the difference from the right ascension, and you shall have the oblique descension of the Sun or any Starre, whose right ascension and difference of ascensions is knowne. But it is to be understood, that this manner of operation, doth serve no longer than you are upon the North side of the Equinoctiall. For if the South Pole be elevated, the worke is contrary: for so long as the Sunne is in any of the Northerne Signes, the difference of the ascensions is to be added unto the right ascension, to finde the oblique ascension. And contrariwise, subtracted to finde the oblique descension. Likewise if the Sunne or Star be in the Southern Signes, then is the difference of ascensions, subtracted from the right ascension, to finde the oblique ascension, and added, to finde the oblique descension.

*The end of the Second Book.*

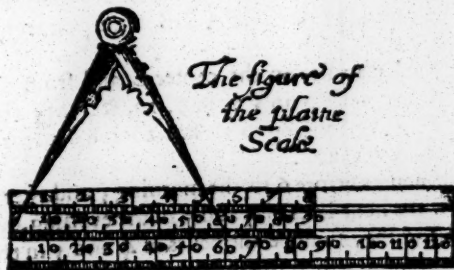




# THE SEA-MANS GLASSE:

## *The Third Book.*

Shewing how by the *Plain-Scale*,  
to delineate *Houre-lines* upon all kinde of  
*Upright Plains*, either *Direct* or *Declining*,  
in any *Latitude*.



### CHAP. I

*How to draw hour lines upon an Horizontal  
Plain, in any Latitude.*

**V**ith the Radius of your line of Chords, upon E as a  
Center, describe the Circle ABCD, and crosse it with  
the diameters AB; and CD. This done, out of the line of Chords

take the complement of the Latitude of your place (which we here suppose to be *London*, whose latitude is 51 deg. 30 m. and its complement 38. deg. 30 m.) which set from B to G, from G to N, and from D to M; then lay a ruler from A to G, and it will cut the line C D in H, and from A to N it will cut C D in O, and from A to M it will cut the same line in F.

This done, upon O (as a center) place one foot of your compasses, and extend the other foot to F, and with this distance describe an arch of a circle, which (if the rest of your worke be true) will fall just in the points A and B, and so constitute the arch A F B, representing the Equinoctial Circle, and so we shall hereafter call it.

Having drawn the Equinoctial A F B, divide the Semicircle A D B, into 12 equall parts in the points \* \* \*, &c. Then laying a ruler to the Center E, and every one of these marks \* \* \*, &c. it will divide the Equinoctial circle into 12 unequall parts in the points ● ● ● ● &c.

Again, Lay a ruler to H, and every of these unequall parts ● ● ● ●, &c. it will cut the semicircle A D B in the points 7, 8, 9, 10, 11, 12, 1, 2, 3, 4, 5 and 6.

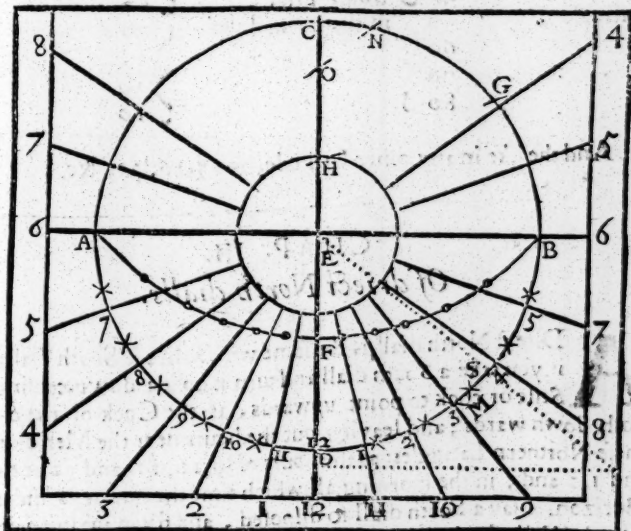
Lastly, If you lay a ruler on the center E, and from thence draw right lines to the severall points 7, 8, 9, 10, &c. they shall be 12 of the true houre-lines belonging to an horizontall diall for the latitude of 51 degrees, 30 minutes.

But for the houres before 6 in the morning, and after 6 at night, do thus; draw the hour lines of 4 and 5 in the evening, quite through the center E, and they shall be the hours of 4 and 5 in the morning; also, 7 and 8 in the morning drawn through the center, shall give the hours of 7 and 8 at night, as in the figure.

Now, for the Stile or Cock of your diall, you must take out of your line of Chords, the degrees of your Latitude, viz. 51 degrees, 30 minutes, and set it from D to S, and draw the line D S, so shall the triangle D E S be the just pattern for the Cock of your diall; which being made of brasse, or the like, and set exactly upright upon the houre line of 12, your diall is wholly finished,

VV  
An

An Horizontall Diall for the Latitude of 51 deg.  
30 minutes.



CHAP: II.

Concerning direct South Diats.

**A** Direct South diall is no other then an horizontall diall, the making whereof is before described, the difference consisting only in the numbring of the houres, and in the placing of it, the one being to be fixed on a poste or the like, and the other to be fixed to a Wall which exactly beholds the South, I say here is no other difference, for

An

## The Sea-mans Glass.

|                | degrees |                    | degrees |
|----------------|---------|--------------------|---------|
|                | 10      |                    | 80      |
|                | 20      |                    | 70      |
| An Horizontall | 30      | Will be a direct   | 60      |
| Diall for the  | 40      | South Dial         | 50      |
| Latitude of    | 50      | in the Latitude of | 40      |
|                | 60      |                    | 30      |
|                | 70      |                    | 20      |
|                | 80      |                    | 10      |

And the like in any other Latitude, as 15, 16, 33, &c.

## CHAP. III.

*Of direct North dialls.*

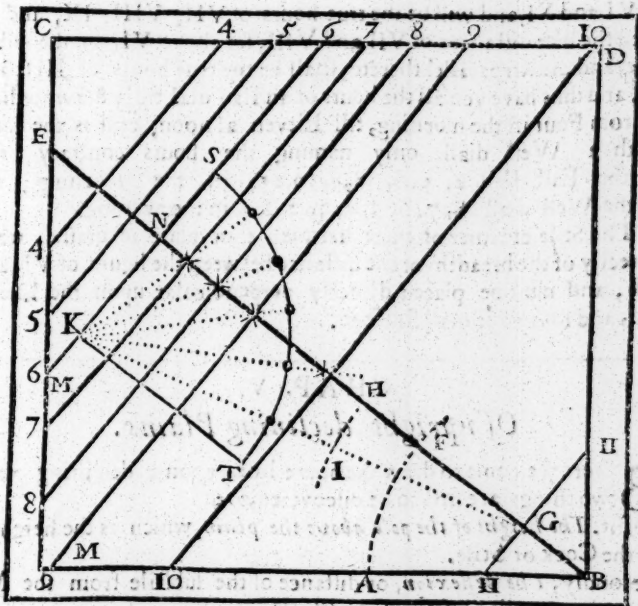
**A** Direct North diall, is the same with a direct South diall; for, if you take a South diall and turn it upside down, causing the stile or cock to point upwards, as the Cock of the South doth down wards; and leaving out the hours near the Meridian, in these Northern Latitudes; as the hours of 9, 10, 11, and 12 at night, and 1, 2 and 3 in the morning, all which time the Sunne is under the Horizon. I say a South diall so disposed, and fixed against a direct North Wall, shall give you the true houre of the day.

## CHAP. IV.

*How to draw the border lines upon a direct East or West plain.*

**A** Direct East or West plain, is such a plain as direct lyeth open to the East or West points of the heavens; as the North and South plain, do to the North and South points. To make such a Diall, upon the plain C B D M. (in some conveni-

convenient place thereof towards the lower part) assume the point B, then with the radius of your line of Chords, upon B as a center, describe the obscure arch A F, then from your Chord, take the Complement of the Latitude of your place, 38 degrees, 30 minutes, and set it from A to F, then from B, through F, draw the line B E, representing the Equinoctiall Circle, which in these plaines, (as also in a Polar Diall) becomes a straight line. In this line E B, assume two points,



one towards one end, and the other towards the other end of the same line, as the points G and N, one for the hour of VI, as N: the other for the hour of XI, as G: through these two points N and G, draw two right lines quite through your plain, perpendicular to the Equinoctiall line BE, as in the figure, which two lines shall represent Eleven and Six a clock. This

This done, upon the point G, with the radius of your Chord, describe an occult arch of a Circle HI, and set thereon 15 degrees from H to I, then from G, through I, draw the line GK, cutting N Min K, On K, as a center, with the radius of your Chord, describe the quadrant KST, which divide into 6 equal parts in the points ● ● ● ●, through which points and K, draw the lines, K●, K●, &c. cutting the Equinoctiall EB in \* \* \* \* &c. Through these points \* \* \*, &c. draw right lines quiet through your plain perpendicular to the equinoctial, which will be parallel to your lines of VI, and XI, and will be the true hours of VII, VIII, IX, and X, then the like distances of VII and VIII, set above VI, on the other side, and drawn parallel thereto, shall be the true hours of IIII, and V. and thus have you all the hours of an East dial truly drawn, which is from Four in the morning, till Eleven at noon, and is the same with a West dial only naming the hours contrary: for, in the East dial 4, 5, 6, 7, 8, 9, 10, 11, in the morning, are in the West dial 8, 7, 6, 5, 4, 3, 2, 1, h in the evening.

The Stile of either of these dials, is a 1 in plate of brasse, made directly of the breadth of the distance between the hours of VI, and IX, and must be placed directly perpendicular upon the line of VI, and so is your diall finished.

## CHAP. V.

### Of upright declining Plains.

**B**Efore we come to draw the Houre lines upon a declining plain, two things are first to be discovered, viz.

First, *The height of the pole above the plain*, which is the height of the Cock or Stile.

Secondly, *The deflexion*, or distance of the subtile from the Meridian or line of Twelve a Clock.

#### 1. To finde the height of the Pole above a declining Plain.

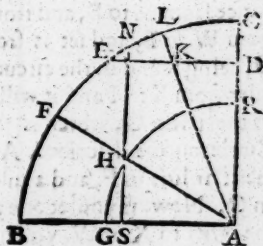
With



**VV**ith the radius of your line of Chords, upon A, as a center, describe the Quadrant A B C, then your Latitude being 32 deg. 30 min, take it out of your line of Chords, and set it from B to F, and draw the line E D parallel to A B, cutting the line A C in D, then with the distance D E, on the center A, describe the Quadrant G H R. Then supposing your plain to decline 30 deg. sec 30 deg. from B to F, in the Quadrant B E C, and draw the line F A cutting the Quadrant G H R in H, through which point H, draw the line S H N parallel to C A, and cutting the Quadrant B E C in N, so shall the arch C N be the height of the Pole above the plain, and in this example contains 32 deg. 37 min.

2. To finde the Deflexion, or the distance of the Substile from the Meridian.

Out of this figure, take the distance H S, and set it in the line D E, from D to K; through which point K, draw the line A K L, cutting the Quadrant B C in L; so shall the arch C L be the distance of the Substile from the Meridian: and in this Example will be found to be 21 degrees 42 minutes.



CHAP. VI.

How to draw the Houre-lines upon an upright Plain declining from the Meridian towards the East or West.

**VV**e will here take for Example a South erect plain, declining Eastward 30 deg.

K.

Having,

Having (by the Fifth Chapter of this Book) found the Declination of such a plain to be 21 deg. 42 min. And the height of the stile (by the same Chapter) to be 32 deg. 37 min. we may proceed to draw the Diall in manner following.

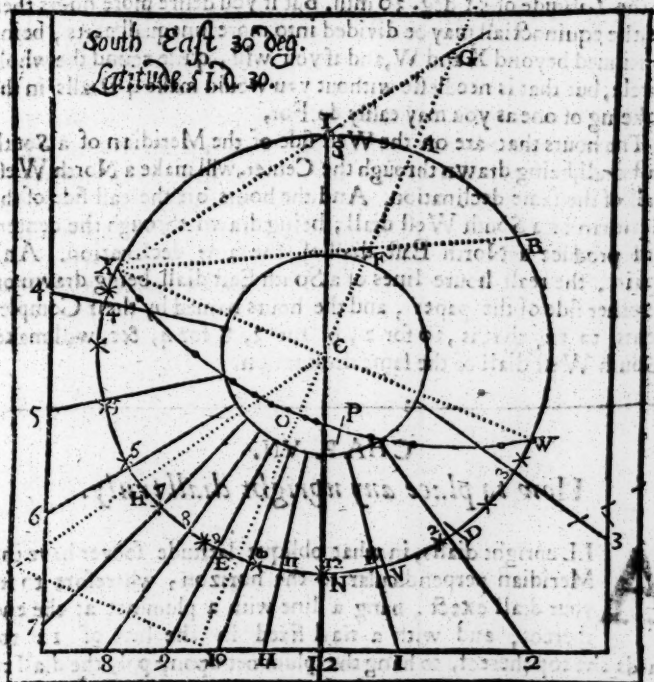
With the radius of your line of Chords, on the Center C, describe the Circle XNSW; and in it, draw SN through the Center C, for the Meridian, or line of 12. Then the declination being found to be 21 deg. 42 min. set that from N to E, and draw the line EC through the center to G; This line representeth the Subtilar line of your Diall, upon which line the stile or Cock must stand. Also, out from your line of Chords take 32 deg. 37 min. the height of the stile, and set that distance from E to H, and draw the line CH for the stile of your Diall: so shall the Triangle ECH, be the true pattern for the Cock of your Diall.

The Subtilar line EC being drawn, draw the line XW through the center C, and perpendicular to EG. This done, take the distance EH, (which is equall to the Stiles height) and set that distance from A to B, and from W to D. Likewise, take the distance from W to B, and set it from B to I. These three points I, B and D, being found in the circumference of the Circle XNSW, lay a ruler from X to I and it will cut the subtilar line EC being extended in the point G, which is the center upon which the equinoctial Circle must be described. Again a ruler laid from X to B, will cut the subtilar line in F, and a ruler laid from X to D, will cut the subtilar line in O. Now, if you set one foot of your Compasses in G, and extend the other to X or W, you may describe the Equinoctial circle XO W, which (if you have not erred in your former worke) will passe exactly through the point O in the subtilar line before found. In the next place, if you lay a Ruler from D to N, it will cut the Equinoctial circle in P, and a ruler laid from C to P, will cut the Diall circle in V.

These things being performed, the next thing is to draw the hour lines, which will be easily effected if you observe the former directions.

First, from the point V last found, begin to divide your hour circle into 24 equall parts (or only one half of it into 12 parts) which you may do by taking 15 deg. out of your line of Chords and

set that distance on both sides of V at the marks \* \* \* &c. so many times as the plain is capable of hours.



This done, If you lay a ruler on the center *C*, and every of these points \* \* \* &c. you shall divide the equinoctial Circle into 12 unequal parts in the points ● ● ● ● &c. Now a ruler laid from *F* to every of these unequal points ● ● ● ● &c. will divide the houre circle into 12 other unequal parts marked with 4. 5. 6. 7. 8. 9. 10. 11. 12. 1. on the one side of *V*, and with 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 1. on the other side of *V*.

Lastly, a ruler laid from C to the severall points 4. 5. 6. 7. 8. 9. 10. 11. 12. 1, 2. 3. and lines drawn by the side thereof they shall be the true houre lines belonging to such a declining plain of 30 deg. in the Latitude of 51 deg. 30 min. But if you desire more hours then 12, the equinoctiall may be divided into more unequall parts, being continued beyond X and W, and if you will, quite round the whole Circle, but that is needlesse without you would make 4 Dials in the making of one as you may easily do. For,

The hours that are on the West side of the Meridian of a South East diall, being drawn through the Center, will make a North West diall of the same declination. And the hours on the east side of the Meridian of a South West diall; being drawn through the center, will produce a North East diall of the same declination. And Again, the reall houre lines of a South East diall being drawn on the other side of the paper, and the hours named by their Complements to 12, that is, 10 for 2, 9 for 3, 8 for 4, &c. will make a South West diall of the same declination.

## CHAP. VII.

*How to place any upright diall truly.*

**A**Ll upright dials, in what oblique latitude soever have the Meridian perpendicular to the horizon, wherefore to set your diall exact, hang a line with a plummet at the end thereof, and with a nail fixed in the line of 12 towards the top thereof, to hang the plummet upon, apply the diall to the place where it is to be fixed, so that the line and plummet may hang just down upon the line of 12, neither inclining on one side or the other, the diall thus fixed if the declination were truly taken, and the diall rightly made, by the former directions, shall at all times (the Sun shining upon it) give you the true hour of the day.

## CHAP. VIII.

*How to insert the halve and Quarters of hours in all dialls.*

**T**He halves and quarters of hours are drawn in all plaines by the same rules, and the like reason, that the hours are inserted. Therefore take notice that if you would insert the halfe hours into any diall, you must divide your Equinoctiall Circle into 24 equall parts instead of 12, and if you would insert the quarters, then you must divide it into 48 parts, and then proceed in all respect, as you did for the whole hours.

## CHAP. IX.

*How to finde the declination of any upright Wall.*

**T**He declination of a plain is an arch of the horizon comprehended between the pole of the plains horizontall line, and the meridian of the place.

To finde this declination, two observations must be made, the Sun shining, and both at one instant of time (as neer as may be.) The first is the horizontall distance of the Sun from the pole of the plain. The second is the Suns Altitude.

First, to finde the horizontall distance. Apply the side of a Quadrant to your plain, holding it (as neer as may be) horizontall, that is to say, leuell, Then holding up a thrid and plummet, which must hang at full liberty, so that the shadow of the thrid may passe directly through the center of the Quadrant, then diligently note through what degree of the Quadrant the shadow passed, and count those degrees from the side of your Quadrant which is perpendicular to the plain, for those degrees are the Horizontall distance.

Secondly, At the same instant, take the Suns altitude, these two being heedfully taken, will help you to the plains declination by the rules following.

By the 17 or 18 Chapters of the Second Book find the Suns Azimuth. Then observe whether the Sun be between the pole of the plains horizontall line and the North or South points, or not.

If the Sun be between them, adde the Azimuth and horizontall distance together, and the sum of them is the declination of the plain.

If the Sun be not between them, subtract the lesser of them from the greater, and the difference shall be the declination of the plain. These rules shew you the quantity of your plains declination, But

### CHAP. X.

*Shewing how to know whether your plain declines from the Meridian towards either the East or West.*

**Y**ou must take notice in your observation, that if the Meridian point fall between the Azimuth and the pole of the plains horizontall line, then doth the plain decline to the Coast contrary to that wherein the Sun is, that is to say, if the Sun be to the Eastward of the Meridian, the plain declines to the Westward, But if the Meridian point be not between the forementioned distance and the pole of the plain, then doth the plain decline to the same Coast in which the Sun was at the time of observation.

### CHAP. XI.

#### *Concerning Polar Dials.*

**A** Polar diall is made in all respects as an East or West Diall is made, onely the line of 6 a clock in the East or West Diall, is 12 a clock in the Polar Diall, the houre of 7 is 1, of 8 is 2, of 9 is 3, of 10 is 4, and of 11 is 5. Also the houre of 5 in the East or West Diall, is 12 in the Polar, of 4 is 10, of 3 is 9, of 2 is 8, of 1 is 7, &c. The Cock of this Diall is a plate of Iron or Brasse made of the breadth between 12 and 3 a clock, and set per-



pendicular upon the line of 12, as in the East or West Diall it is upon the line of 6. In these Dialls the Equinoctiall line is to lie parallel to the Horizon, and not to be elevated according to the complement of the Latitude of the place, as in the East or West Diall it is.

CHAP. XII.

*Concerning Equinoctiall Dialls.*

**A**N Equinoctiall Diall is of all other Dialls, the most easie to make, for if you describe a Circle, and divide it into 24 equall parts, and draw lines from the center through every one of those equall parts, the lines so drawn shall be the true houre lines.

For the stile of these Dialls, It is no other but a streight Wyre of any length set perpendicular in the Center of the Circle, whose shadow shall give the true houre of the Day.

CHAP. XIII.

*Of such Plains as decline very far from the East or West towards the Meridian as 75, 80, or 85, deg. above which plains the Pole hath small Elevation.*

**S**uch plains as decline above 60 degrees the houre lines will come very close together, so that if they be not extended very far from the center, there will be no sensible distance between hour and hour.

To remedie this inconvenience, there are severall wayes, I will instance only in one which is familiar and easie, and that is this,

When you have drawn your Diall on a large sheet of paper, fix it on some large Table or smooth Floor of a Room, if the Diall you are to make be very large, as 5, 6, or 7 foot square, then by the side

of a long Ruler laid to the Center and every hour line, as also to the stile and Subtile, draw lines to the full extent of the Table or Flour, and you shall finde them to be of a competent largnesse. Then according to the bignesse of your plain, cut off the hours. Stile and Subtile, leaving the center quite our, and your work is finished.

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## CHAP: XIII

*Concerning Declining Reclining and Inclining  
Dials.*

**V**VE should now shew the manner of drawing houre lines upon declining reclining and inclining plains, of which there are severall varieties, and many cautions, which in this place and at this time, would be too many to ennumerate: but if this which hath been already delivered concerning Upright decliners shall be kindly accepted, it shall animate me to do the like for all other plains whatsoever.

---

FINIS.

## ADVERTISEMENT.

**N**Ote, that this Scale and all other Instruments for the Mathematicks, are made by *Walter Hayes*, at the Crosse daggers in Moore, Fields next doore to the Popes head Tavern, London.

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